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OUT of DOOR STUDIES IN GEOGRAPHY

BY F. M. FULTZ

PART II.

Mountain Ranges

A Study of
The Sierra Nevada

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OUT OF DOOR STUDIES IN GEOGRAPHY

II

The Formation of Mountain Ranges

A STUDY OF THE SIERRA NEVADA

By
FRANCIS M. FULTZ, A.M.
Superintendent of City Schools
BURLINGTON, IOWA

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PREFACE

The cordial reception of the first book in "Out of Door Studies in Geography" by teachers and students of the subject and its success in the class room have led to the early putting forth of this second one of the series.

This book is devoted to the purpose of trying to make clear the processes in mountain making and to the endeavor of conveying a truthful understanding of the actual conditions existing in a typical mountain range.

As in the first book, difficult, scientific terms and phrases are avoided where-ever possible. Also the descriptions have been written with the intention of making them easily read by grammar grade pupils.

All the illustrations are from photographs, many of them taken expressly for this purpose. Excepting where credit is otherwise given, the photographs were taken by the author.

While what the book contains is largely out of the author's own experience and study, yet acknowledgment is due Prof. Joseph N. LeConte, of the University of California, for valuable information and data.

FRANCIS M. FULTZ.

Burlington, Iowa, March 1, 1909.

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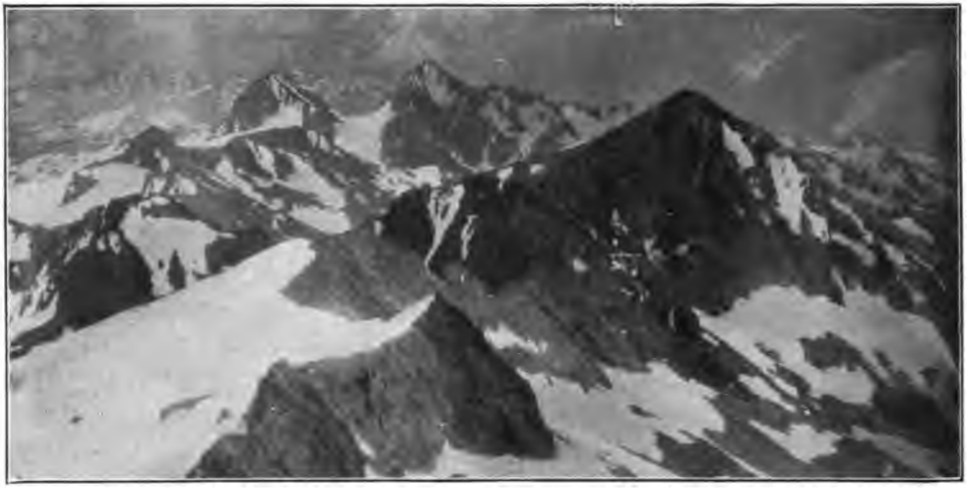


1. A VIEW IN THE HIGH SIERRA.

Mt. Ritter (in the center), Rodgers Peak (on the right) and Banner Mountain (to the left of Ritter). Mt. Ritter and Rodgers Peak are both over 13,000 feet, and Banner Mountain very nearly 13,000 feet. This region lies about twenty-five miles east of the Yosemite Valley. It is one of the wildest and most rugged parts of the Sierra. This picture was taken from the summit of Mt. Lyell, another mountain over 13,000 feet.

A STUDY OF MOUNTAINS.

INTRODUCTION.

By far the larger number of all the people of the earth live on the plains, or on the plateaus bordering the mountains. A very much smaller number live in the valleys. Comparatively few live in the narrow mountain valleys and on the mountains themselves. So, most people do not think of the mountains as a desirable place to make homes. It is true many people are interested in them, but for the most part it is because they enjoy spending their vacation there during the hot summer months, or that they like to go there to hunt and to fish.

Those who visit the mountains cannot help but notice the folded and crumbled strata, the tilted layers, the great fissures, the veins and dikes, and the long slopes of loose rock material. But to most of them these things do not have the same interest as do the swift, clear streams with their cascades and waterfalls, or the deep gorges and the towering peaks. Yet these are the very things that tell us how mountains were made. So I hope when you visit the mountains you will look for them. If you do, you will find them, and your mind will soon be busy with a thousand questions, the answers of which will bring you far greater pleasure than the mere vision of towering peaks and deep canyons. It is enchanting to visit the cascades and waterfalls; it is awe-inspiring to look into the deep canyons; it is exciting to climb the rock crags; it is glorious to view from some high peak a wide expanse of mountain and plain. But to be able to read the history of it all gives a deeper and more enduring pleasure.

Mountains are formed either by material thrown out of the interior of the earth by volcanic action; or through the elevation of the earth's surface by forces within the earth. The peaks and ridges, the canyons and valleys, and the other features which give mountains such a rugged surface, are the work of the tearing-down forces.

Photo from Wm. H. Rau. 2. A VIEW IN THE ALLEGHENIES.

I.

MOUNTAIN RANGES.

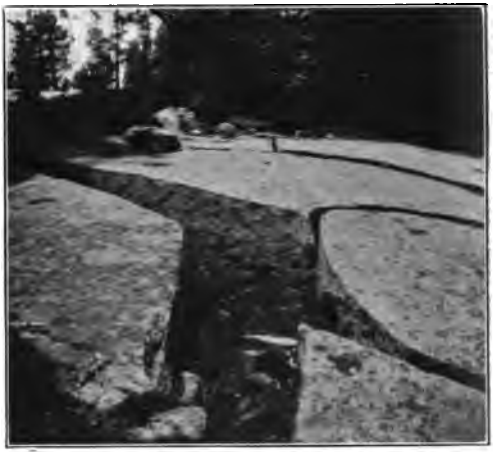
There are no extensive ranges of volcanic origin. Volcanic mountains are usually single peaks which stand out by themselves. They are often of great height, and are impressive because they rise so high above the surrounding country. Such mountains, too, on account of their altitude, are usually covered with snow about the summits throughout the entire year, which adds to their impressiveness.

Great mountain ranges are formed by a portion of the earth's crust being pushed upwards. The area thus elevated is usually much longer than it is wide. One of the principal causes of the pushing up is the slow contraction of the earth. The earth is constantly losing its heat, and as it cools off it grows steadily smaller. This contraction forces the surface upward in some places. Thus a mountain range begins.

When these uplifts take place, it often happens that a number of folds are formed, making parallel ranges of mountains near each other. These uplifts are sometimes very complex, and along with them there is always more or less breaking of the rock strata which form the crust.

Sometimes the movement has been rapid and accompanied by violent earthquakes. Where this happens, usually extensive fissures are formed on one side of the area of disturbance, and a great block of the earth's crust shoved upward along the line of this fissure. In such a case, the mountains on that side present a steep, bold face, while the other side will be a long gentle slope. Mountains of this kind are known as the "block" type.

As soon as mountains begin to rise, gravitation, frost, running water and other erosive forces commence to tear them down, so that while the mountains are still rising, their tops are being eroded and the material carried away. These erosive forces continue to act long after the pushing-up process has stopped. The result is that an old mountain range is rounded off and has no sharp outlines. Whenever you see a rough and rugged range of any considerable altitude, you may be sure it is a range of comparatively new mountains, where the cutting down forces are still actively at work.



3.

GRANITE IN THE SIERRA NEVADA BROKEN BY THE ACTION OF FROST.

Explain how the blocks are pried farther and farther apart by the same agency.

The top of a new mountain range is made up of shallow ravines and broad ridges. In middle life it is rugged with sharp ridges and jagged peaks, between which are deep gorges and canyons. In old age the peaks and ridges have been worn away and the whole range lowered more nearly to the level of the surrounding country. What remains of the former range are mountains of low altitude and rounded slopes which extend down into the broad shallow valleys, the whole extent of which is apt to be covered with forest. When the erosion has gone on so far that nothing of the range remains but a few scattered hills, the region is called a *peneplain,* meaning almost a plain

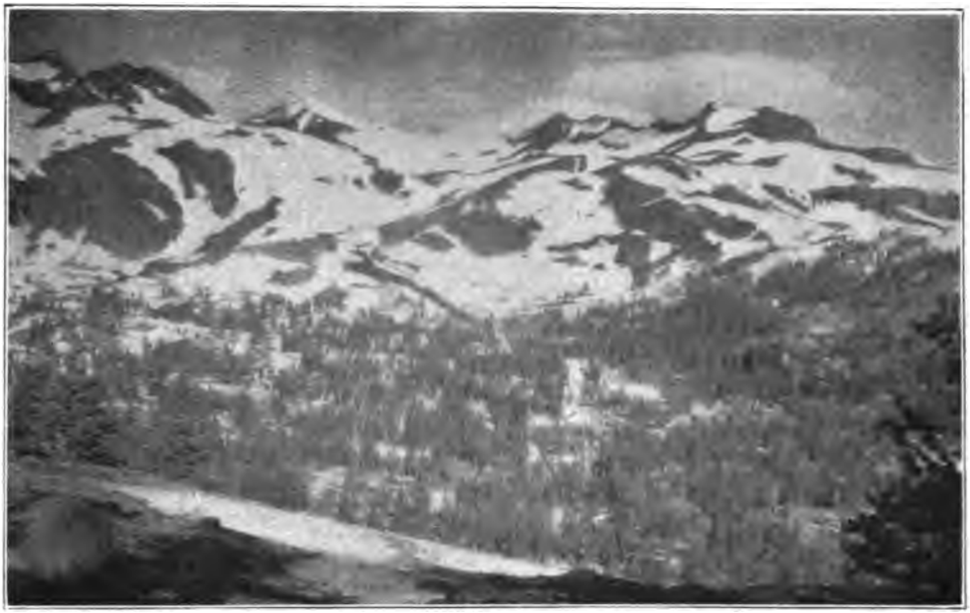
4.

SANDSTONE PILLARS.

These sandstone pillars are fragments of the few sedimentary rocks still remaining on the summit of the Sierra Nevada. What agencies are actively at work tearing them down?

The *snow line* on a mountain is the line above which the snow lies throughout the whole year. Of course there is no sharp line which marks just how far up the snow melts away, for during some seasons that point is much farther up than during other seasons, depending on the amount of snow that has fallen that year, whether the summer is unusually warm or cool, the prevailing direction of the winds, and other lesser causes. So it can be seen that the snow line is a strip of uncertain width rather than a sharp line. In the northern hemisphere the snow line is much farther down the mountain on the north side than on the south. In the tropics the snow line is at the altitude of 15,000 feet or more above the sea level; at the middle of the north temperate zone it is from 11,000 to 12,000 feet; it grows steadily lower to the northward, until at the Arctic ocean it is practically at the sea level.

The *timber line* is at the highest point on a mountain at which trees grow. Like the snow line it is not a sharply drawn line, but rather a region where, as one goes higher, the trees grow more dwarfed and become fewer and fewer until they altogether cease.



5. TIMBER LINE IN THE SIERRA NEVADA.

This picture was taken about the first of August, yet it shows the snow still lying throughout the basin where the forest grows. The altitude is about 10,000 feet. The high peaks of the mountains surrounding this basin run up to over 13,000 feet. Note that the range in the background shows fully 3000 feet above timber line.

At the middle of the north temperate zone it is usually at an altitude of from 10,000 to 11,000 feet above sea level. Farther south it is higher up; farther north it is lower.

On the belt which lies between the timber line and the snow line dwarfed bushes and low Arctic shrubs are sparsely scattered. Lichens are more abundant.

A *mountain pass* is a place in a range which admits of people crossing freely from one side to the other. It is usually where the range is lower, but it may be well up on the highest part of the range. It is much more important that the slope on either side be gentle enough to climb than that the summit be of low altitude. Wagon roads and horse trails are built over mountains

6. FAREWELL GAP.
A mountain pass in the Sierra Nevada which leads over the Western Divide into the Kern basin.

by way of the passes; and railways, too, unless they pierce the summit of the range by means of tunnels. Passes most frequently occur where two streams, one on each side of the range, rise near the same point on the summit.

On account of their ruggedness and height, mountains are often greater barriers to traffic between peoples than the oceans are. So nearly impassable are some ranges that people dwelling in a valley on one side have no communication at all with those living in the valley close on the other side. It has often happened, too, that mountains have been the means of preserving a people by preventing invasion by the armies of a hostile nation.

In the early history of our country the Alleghenies were a formidable barrier to westward emigration, and the settlement of the interior was delayed many years. Yet the Alleghenies were not mountains of very great height, nor exceedingly rough and rugged. If they had been of the alpine character of the Sierra or Cascade ranges, the settlement of the interior would have been delayed many years longer.

Railroad building in the mountains is usually difficult. To reach even the lowest passes often requires great engineering skill. Frequently to climb the necessary grade, the road must wind backward and forward many miles to overcome the altitude.

The various ranges of mountains in North America west of the Great Plains, taken together, are usually known as the North American Cordillera. But some writers call them the Western Cordillera, to distinguish them from the mountains along the eastern coast which they group under the name of the Eastern Cordillera. Thus they use the name *cordillera* to mean a great group of mountain ranges which are somewhat closely connected.

Four systems of ranges make up the Western Cordillera in the United States,—the Coast Ranges, the Sierra and Cascade Ranges, the Ranges of the Great Basin and the Rocky Mountains. Of these the Rocky Mountains are by far the most extensive, the Coast Ranges the newest, the Basin Ranges the most barren and the Sierra and Cascades the most rugged and alpine.

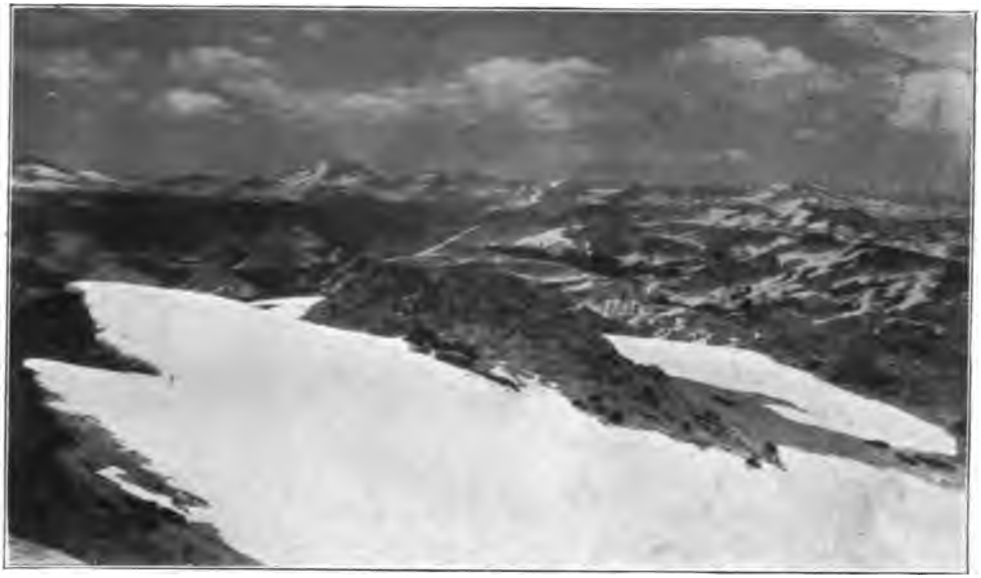
The mountain ranges of the United States have a general north and south trend, although nearly all of them vary from due north and south. For the most part they take the same general direction as the coast line nearest which they are situated. Thus those along the eastern coast from the north to the south bear towards the west, while the western mountains from the north to the south bear towards the east.

Mountains afford the best opportunity to study the action of the forces which shape the earth's surface. There may be seen the folded, tilted and broken strata which testify of the tremendous disturbances through which the earth's crust has passed. There, too, gravitation, frost, running water and the other tearing-down forces are most actively at work. Of course to get a complete knowledge of the building up of mountains and their wearing away, one must study mountains which are still being uplifted, those which are in the prime of their life and others which are old and well worn down to the general level again. But such a study requires much time; more than the writer intends the present study shall cover. However, a good knowledge of the mountains may be had from a careful study of a range which is fully uplifted, but which is still in the vigor of life.

Such a range is the Sierra Nevada. There the uplifting is practically finished and the tearing down forces have been just long enough at work to produce mountains, which on the slopes contain gorges of profound depth. There, too, may be seen the titanic work done by a great glacier. Small remnants of this old ice sheet still remain on the flanks of some of the higher peaks, while a perpetual snowfield covers the crest of the range. Rivers abound, and the eroding effects of running water are everywhere apparent. There are extensive forests also, and nowhere else is there better opportunity to see the distribution of plant life as affected by altitude. There, too, the volcanic forces have been at work, and as evidence of their activity have left many craters and lava flows. Earthquake effects are plentiful and landslides numerous. On the east is the Great Basin, the desert-like condition of which the range is largely responsible for. On the west is a great valley, of semi-tropical climate, for the fertile soil of which it furnishes life-giving streams of water.

On account of all these things the writer chose the Sierra Nevada as a region for personal study and investigation, and what he tells is largely that which he himself has seen and experienced.

First there will be a general description of the range as a whole. Then will follow detailed studies of the individual features, such as the high peaks, passes, lakes, snowfields, glaciers, rivers, gorges, forests, meadows and others that are considered of sufficient importance.



7. GENERAL VIEW ACROSS THE TOP OF THE SIERRA NEVADA.
Looking southeast from Mt. Hoffmann.

II.

THE SIERRA NEVADA.

The Sierra Nevada is one of the most prominent and impressive ranges of the Western Cordillera. In almost every way it is the equal of any of the other great ranges of the system, and in height and alpine ruggedness surpasses them all.

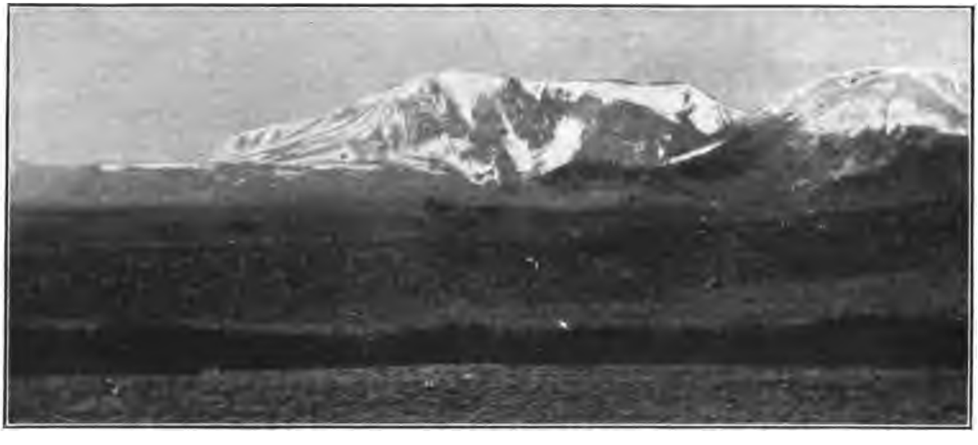
The range is wholly in California, lying near the eastern border, which it follows somewhat closely. From the northern end, near the north line of the state, towards the south it bears about 30 degrees to the east. Both at the north and south it blends with the Coast Range, so that its exact limits in these directions cannot clearly be defined. Roughly stated, it extends from Tehachapi Pass, about latitude 35° 15', to Mount Shasta, latitude 41° 25', a distance of about 500 miles. Throughout its entire length the crest makes nearly a straight line. At its greatest width, which is north of Sacramento, it is about 80 miles across. The width gradually decreases toward the south until, near the southern end, in the region of the Kern river, it is less than 50 miles. While the range is wider toward the northern end, in general it is also much lower in that region and less rugged. However, there are a few high, isolated peaks, such as Mount Shasta; but they are volcanic cones. From nearly the center southward, in the region of the narrowest part, the range is highest and most sublime. There, for nearly 150 miles, the main crest passes through group after group of mountains, whose peaks rise to 13,000 feet or more above sea level, and many of them to 14,000 feet. And throughout this stretch there are but one or two passes between the groups lower than 10,000 feet. In this region too, the perpetual snowfields are most extensive.

The Sierra Nevada region is the result of two distinct upheavals of the earth's crust. The first disturbance was gradual, the force exerted being lateral pressure both from the east and west. It is not possible to tell to how great a height the region was elevated, but it must have been considerable. Great erosion followed the first upheaval. Almost all the sedimentary strata were cut away and everywhere the older granite rocks left exposed, into which the rivers had cut deep channels. Then followed the second period of disturbance, in which the movement was violent and probably rapid. It is probable, too, that earthquakes were frequent. A fissure was opened along the eastern side for several hundred miles and a great block of the earth's crust embracing the old region was pushed bodily upward along that line, making the abrupt eastern face and the long slope to the west which now are such prominent features of the range.

Along this fissure at the eastern base of the range, there has been considerable eruptive activity, the evidence of which is seen in volcanic cones and lava flows. These cones and lava fields are also found some distance back from the eastern border of the range, showing that the disturbance extended to some distance from the main fissure.

The range may be said to be now in the prime of its life. There are occasional slips along the line of faults which were formed at the time of the last general upheaval, which may be classed as the creative forces still at work. The destructive agencies are active. There is a comparatively large precipitation and the erosion resulting from running water is considerable. It would be much greater if the sedimentary strata were not altogether cut away and from the fact that much of the granite is hard and compact. Freezing and thawing on the higher parts of the range constitute one of the most destructive of the tearing-down agencies.

The whole of the higher part of the range was completely covered with ice during the glacial period and the cutting away resulting from the movement of the ice was enormous. Excepting on the very highest peaks, the rocks everywhere bear the evidence of the severe scoring they received from the old glaciers. In many places the



8. ABRUPT EASTERN FACE OF THE SIERRA NEVADA, MONO VALLEY, CALIFORNIA.

The dark line across the foreground is a strip of timber along Walker Creek. The rest of the foreground clear up to the mountains is a desert upon which nothing but sagebrush grows.

granite still bears a highly polished surface, so smooth as to be dangerous to walk upon where there is considerable slope. There are still a few small glaciers remaining, but they exhibit little motion and play a very little part among the present destructive forces.

Mention has been made of the abrupt eastern face and the long western slope. Nearly nine-tenths of the whole area lies west of the main crest. These features of the range appear very evident when viewed from one of the higher peaks. The top of Mount Whitney is 14,502 feet above the sea. The Owens valley at its foot, five miles east, is about 6,000 feet, making a slope of about one foot in three, while the average slope to the west is not more than one foot in twenty-five or thirty.

The eastern face in many places is perpendicular for hundreds of feet. The streams are short, swift, and made up of falls and cascades. They flow into the deserts and feed salt lakes, which, with the exception of Mono and Owens, are of no considerable size. Since the streams are short, there are no great canyons. There are no forests, for there is little precipitation and no level stretches or moderate slopes for trees to grow. At the eastern base is the border of the desert region, and even before one passes from the slope out on to the general level of the plain one notices the change in vegetation.

The western slope is from thirty to sixty miles wide, and, as already stated, the average drop is only about one foot in twenty-five or thirty. There are many good-sized rivers, which all rise among the peaks of the crest. They are swift, clear streams and all have cut deep gorges somewhere along their courses. Nearly all flow directly away from the line of the crest. The Kern, however, is an exception, flowing for forty or fifty miles nearly due southward through a deep canyon which lies between the twin crests into which the range divides toward the southern part. The upper courses of the streams are mostly falls and cascades; the middle courses, deep canyons with nearly vertical walls and flat floors; and the lower courses, V-shaped gorges. The long and nearly uniform slope on the west and the swift rivers which cut through have given rise to the Sierran type of canyon sculpture, which will be described more fully when the canyons are studied in detail. The Sequoia gigantia, sometimes known as the Giant Redwood, is found only here. Others of the large trees are the yellow and sugar pines and the silver and red firs.

The western slope receives a comparatively large amount of rainfall. The precipitation comes mostly during the winter months, and high up on the slope, and on the upper parts of the range, falls in the form of snow. The moisture-laden winds from the Pacific, rising to higher altitudes in order to surmount the range, give up their load, so that, by the time the crest is reached, they have little left. The snow in some places on the higher parts of the range falls to a depth of thirty feet.

The western base of the range is nearly at sea level, and in many places along the southern 300 miles is frostless, so that oranges, lemons and other semi-tropical fruits flourish. A large part of the water from the rivers on the western slope is now used to irrigate the great stretch of farming lands along the eastern part of the California Valley.

From the California Valley during winter the Sierra is a great white range clear down to the foot-hills, which at that time are green. In the summer the foot-hills are brown. Just above these is a wide, dark-green belt which shows where the great forests are, and in which appear the deep recesses of the river canyons. Above the forest belt is the snowy crest of the range, one continuous stretch of white, with here and there a peak somewhat higher than the general level of the crest. It is an impressive sight, and one who journeys through the California Valley cannot help having a desire to visit the top of the range and see for himself the wonders it contains.

Viewed from the eastern side, the range looks like a rugged wall of granite, with steep precipices and abrupt canyons, and topped with snow-clad peaks. The whole seems to form a barrier which cannot be scaled. Yet up some of those abrupt canyons trails have been built.

When viewed from one of the higher peaks, the range to the north and south appears as a jumble of mountains. To many who have never before viewed the top of a range, it is apt to be a confusing sight; for, until they have seen the actual thing for themselves, most people imagine the crest of a mountain range is a sort of ridge which one can follow along without any particular difficulty. In reality, it is very difficult for one to travel along the ridge of a mountain range.

All over the higher parts of the range the atmosphere is clear, and to the north and south vision extends to 75 or 100 miles. To the west there are minor groups of mountains, many of which are but little lower than the main-crest peak upon which you stand, and between which are deep canyons. Just beyond and lower down is the dark-green forest belt. The foot-hills show but little, and the California Valley, from 40 to 60 miles away, looks indistinct in a yellow haze.

To the east the view is down into the desert plain of the Great Basin, with its salt lakes, volcanic cones and barren mountains. Vision out over the desert extends to no great distance, on account of the purple haze which shrouds everything. Even the lakes which lie in close at the foot of the mountains seem to have a veil drawn over them.

Photo from Wm. H. Rau. 9. MT. SHASTA.

I.

THE CREST OF THE MAIN DIVIDE AND THE HIGH PEAKS OF THE SIERRA NEVADA.

The Northern half of the Sierra Nevada range will not average more than one half the altitude of the southern half. It is not nearly so rugged, and is forested entirely to the summit.

The whole northern part of the range is covered with lava flows, while the southern half is largely granite. Near the central part of the range, there is still some of the metamorphic rock, and a number of the high peaks in that part are made up of it.

While in general the northern half of the range is not high, yet Mt. Shasta, which stands at the extreme northern end, is 14,380 feet in altitude, making it one of the high mountain peaks of the United States. It is an old volcanic cone, although the exact limits of the crater can not now be made out. It was undoubtedly much higher once by probably 1000 to 1500 feet, but the action of frost, snows and glaciers has reduced its altitude and rounded off its sharpness.

South of Mt. Shasta the range is dotted with many smaller craters and cones. Lassen's Butte, about 75 miles distant, is the highest of these, having an altitude of 11,000 feet. Around about this peak is the region of the most recent volcanic activity in the Sierra. Many of the cones are so fresh that they have not yet been worn away to any noticeable extent. Even the charred remains of trees are still found under the front of some of the lava flows.

South of Lassen's Butte the mountains rise gradually, until, about the middle of the range, the summit is almost continually above the timber line. Almost due east of San Francisco it reaches 13,000 feet. Within the next 125 miles there are 60 peaks of this altitude, or higher. Mt. Dana, 13,050 feet, is the most northern one of these, and Mt. Langeley, 14,045 feet, a few miles south of Mt. Whitney, is the most southern. South of Mt. Langeley the altitude drops rapidly again, and within 15 or 20 miles is below timber line.

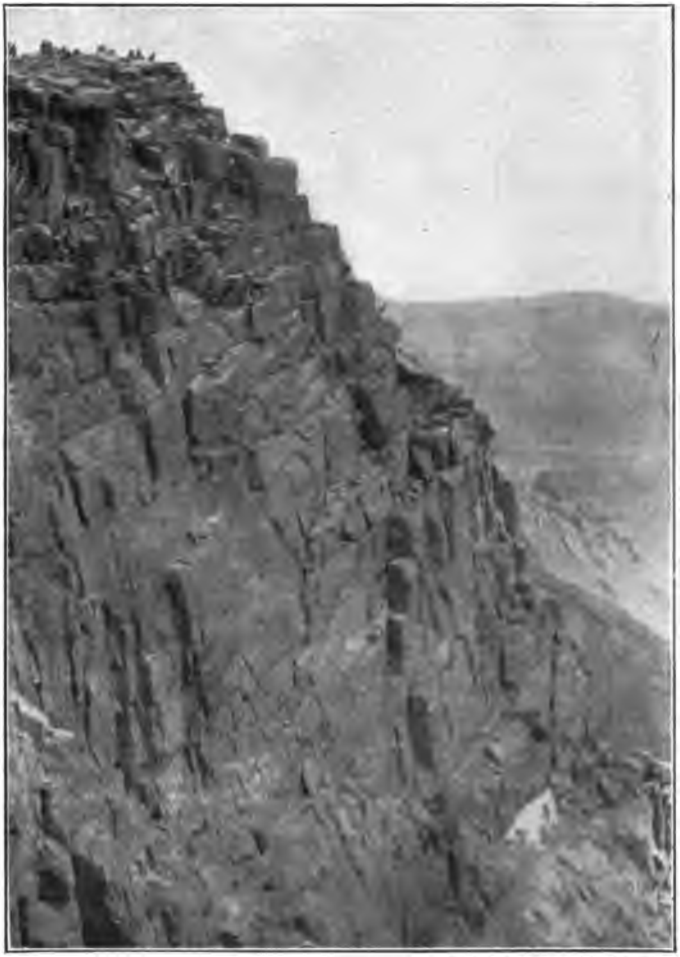
That part of the summit of the Sierra which is above the line of continuous forest is called "The High Sierra." It extends from the Central Pacific Railroad to a few miles south of Mt. Langeley. At the northern end the timber line is at about 9,000 feet; at the southern end, about 11,000 feet. On account of snowfields, steep slopes and other mountainous conditions, the line of continuous forest is about 2,000 feet lower than the timber line.

The length of the High Sierra is about 200 miles; the width is somewhat irregular, varying from 10 to 20 miles. The crest is nearly in a straight line. There are some minor windings, but the deviation is not enough to make them noticeable on an ordinary map.

While the top of the range, when viewed from one of the higher peaks, looks like a confused mass of mountains, yet by carefully picking out the water-partings, the highest line of the crest can be easily made out. This high crest line is called the *main divide.* The main divide passes through most of the high peaks. Of the remainder, the greater number are to the west. Of those just to the east of the main divide, Mt. Williamson, about 10 miles north of Mt. Whitney, is the highest and most rugged. It is only about 120 feet lower than Mt. Whitney itself.

That the top of the range looks like a confused jumble of peaks, is due to the many transverse divides which lie between the rivers flowing to the west. When the great block of the earth's crust which forms the Sierra Nevada was pushed upward, the east face of the range was nearly perpendicular to the height of probably 2 miles, while the slope toward the west was so gradual that the whole top to a considerable distance from the eastern edge was very much of the same level. However, the slope was sufficient for the drainage to seek direct courses to the California Valley. These watercourses have deepened into the profound canyons which intersect the western slope. They are somewhat regularly distributed from 20 to 30 miles apart along the whole western slope. The cutting of the canyons has resulted in leaving high ridges somewhat nearly midway between, which now form separate groups of mountains. These ridges themselves have been cut into numerous peaks and minor ridges by the tributary streams which flow into the greater streams of the deep canyons. Thus we have west of the main divide many minor groups of mountains, some of which are nearly equal in altitude to the peaks of the main divide itself.

Many of the high peaks have a gradual slope from the south and southwest, while on the north and east their faces are sheer for hundreds and sometimes thousands of feet. The abrupt faces on the north are largely due to glacial cirques. Remnants of the old ice sheet which once covered nearly the whole range still linger in these cirques, protected by the mountains from the sun and southern winds. On the east side the main divide peaks are nearly all abrupt. This is due to the original steep eastern face of the whole range. A few of the main crest peaks, and many of those to the west of the main divide, are simply the higher part of a sharp ridge. A few, also, are



10. SUMMIT AND SOUTH WALL OF MT. WHITNEY.

Mt. Whitney is the highest mountain in the United States; its altitude is 14,502 feet. It is composed of granite and its south and east walls are nearly perpendicular.

11. SUMMIT OF THE MAIN DIVIDE OF THE SIERRA NEVADA SOUTH OF MT WHITNEY.

precipitous on all sides. These, of course, are the most difficult to climb.

Mt. Whitney, altitude 14,502 feet, is the highest mountain in the United States. It is one of the main crest peaks, but it is not so impressive as many of the others because of the high elevation of the whole range in its immediate vicinity, and also because it is surrounded by many other peaks almost as high. It is one of the peaks which has a somewhat gradual slope on the south and south-west, and therefore is not very difficult to climb.

A good trail leads to its foot on the southwest, but it requires a two or three days' journey by horse from the end of the nearest wagon road to reach the mountain. This trail stops at an altitude of 12,000 feet, leaving 2,500 feet which is overcome by about three miles of laborious climbing. Although this climbing is very tiresome, it is in no manner dangerous. All one requires is strength and determination. The way up is over rocks, along part of which there is no well beaten trail, although the best course has been marked out by little rock monuments of three or four stones placed one on top of the other.

The top of the peak is about a half a mile long and nearly as wide, somewhat rectangular in outline and rising gently toward the east. The surface is rather rough with granite blocks, much weathered and lying very nearly as they have been weathered out. The top is reached at the southwest corner of the rectangle where it is two or three hundred feet lower than the highest point, which is on the extreme eastern edge. The mountain is precipitous, almost perpendicular, on the north, east and southeast. On the east and southeast it is absolutely sheer, so that a rock thrown from the edge will fall more than a thousand feet before striking. The view from the top is fine, although not so magnificent as from some of the other peaks, farther to the north. This is on account of the many high peaks which are in the close vicinity. The range both to the north and south contains other peaks which rise within two or three hundred feet as high as Mt. Whitney itself. At the foot on the east lies Owens Valley with its desert conditions, made so by the Sierra range taking all the moisture from the west winds. In summer this valley is veiled with a purple haze, as are also the Inyo Mountains to the northeast on the other side of the valley, some 20 miles away. In the valley to the southeast, and only 6 or 7 miles distant in a straight line, is Owens Lake, the largest body of water in the western side of the Great Basin. It receives the drainage of the eastern slope of the range for a long distance toward the north, and has no outlet. Of course it is a salt lake.

To the west about 15 miles is the Great Western Divide, in which there are many peaks rising to nearly 14,000 feet. The most prominent mountains in this range are the Keweahs. The Keweah group is a spur extending from the Great Western Divide for a

12. THE GREAT WESTERN DIVIDE FROM THE SUMMIT OF MT. WHITNEY.

Mt. Whitney is in the Main Divide, or as it might properly be called, the Great Eastern Divide. The Great Western Divide branches off from the Main Divide about twelve or fifteen miles north of Mt. Whitney. The Kern River Canyon lies between the two divides. The top of Mt. Whitney shows in the foreground.

short distance toward the east. Therefore it does not lie in the crest line of the Western Divide. Several of the Keweah peaks are 13,000 feet or over, and the group makes an impressive spectacle. Between the eastern and western divide there is a wide forested valley, midway in which lies Kern River Canyon, a gorge 2,000 feet deep and about 40 miles long. The valley is much cut up by short, steep tributary canyons.

Later, after the other principal features of mountains have been described and studied, there will be given a personal account of the ascent of one of the more difficult peaks.

2.

THE PASSES.

The Central Pacific Railroad goes through Donner Pass, at an elevation of 7,150 feet. This is in latitude 39° 19'. Within 75 miles south of Donner Pass there are 5 wagon roads across the Sierra. The most southern of these is the Sonora Road, which goes through a pass at an elevation of 9,624 feet. Then there is a stretch of 200 miles with nothing but trails across

13. SUMMIT OF MT. LYELL.
The summit runs up to a sharp peak, on the very point of which there is a cairn. The summit is composed of angular granite blocks. On account of its extreme hardness, the granite weathers very slowly.

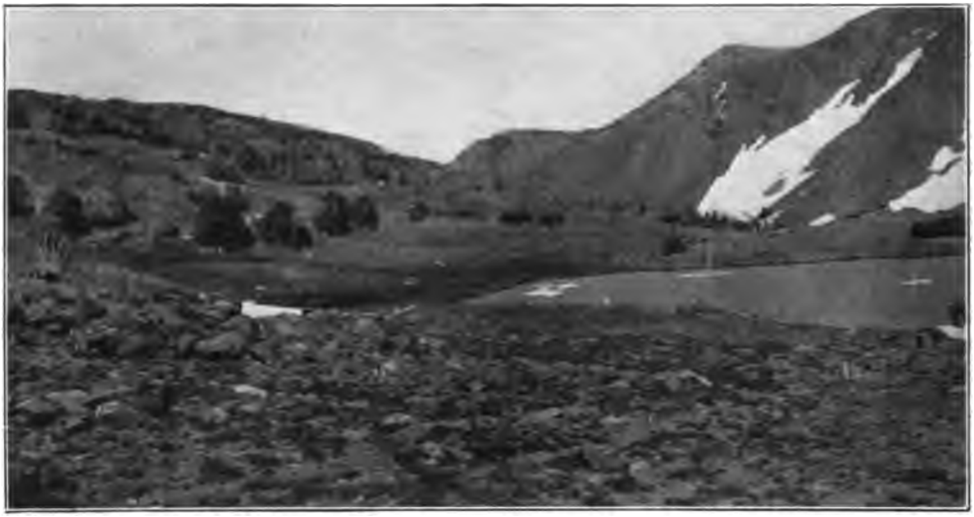
the range. Within this stretch there are but two passes under 10,000 feet. Only a few of the trails crossing through the many possible passes are taken care of, and none of them are well graded.

Some of the best known and most used passes are Mono, Mammoth, and Kearsarge. The elevation of Mono Pass is 10,600 feet, Kearsarge 11,823 feet, and Mammoth about 9,500 feet. Through these different passes go many trails from the California Valley into the Mono and Owens Valleys on the east side of the range, several trails converging at each of them on the west side.

The passes are all notches through the main divide cut out by glaciers. In some instances the highest point is a sharp ridge, but in others there is a considerable distance of nearly level surface where the old glacier has worn out a rounded trough.

The principal difficulty in reaching the passes is on the east side, where the ascent averages nearly 1000 feet to the mile. On the west side the ascent is usually gradual, being about 200 feet to the mile. On the east the summit must frequently be reached by much zigzagging, but on the west the trails lead almost directly into the notch. Glacier lakes are common on the summit of the passes and in the gorges leading up on the east side.

One of the best known and most used is Mono pass, through which various trails from the California Valley go over to the Lake Mono region. These trails lead by the way of Yosemite and Hetch Hetchy Valleys, and points further north. They converge in the Big Tuolumne Meadows about 10 miles west of Mono Pass and go through by a common trail to the



14. SUMMIT OF MONO PASS, 10,600 FEET ABOVE SEA LEVEL.

One of the lakes lying on the saddle of the pass shows on the right. Note the rounded appearance of the saddle, showing plainly that it was the bed of a glacier. The pass is just at timber-line, as the stunted pines show. There is very little soil, the trees growing in crevices of the rocks.

Mono region of the Great Basin. From the California Valley they lead up through the foot-hills along the divides between the rivers, the gorges of the streams being too narrow and precipitous for building roads. Up through the foot-hills and into the forest belt, there are frequent wagon roads; but these end by the time the middle of the forest belt is reached, and from here on into the mountains there are no roads but horse trails.

About where the wagon roads stop, the trails drop into the valleys of the streams, which in that region are flat-floored. About the upper edge of the forest belt the trails are frequently forced up out of the canyons because they become impassable, and from there to the summit follow through the meadows and old glacier valleys.

The trails from Yosemite Valley are the most used of all those going through Mono Pass. There are two of them, and by either one it requires a two days' journey on horse-back to reach Lake Mono. The trails pass up out of Yosemite Valley by climbing the 3,000-foot wall, one at the north side and the other at the southeast end of the valley. Then they pass through the magnificent pine forest which covers the plateaus to the north and east. It is a day's journey on horse-back to the Big Tuolumne Meadows, where there are fine camping grounds. The Tuolumne Meadows are at an elevation of 8,500 feet, and from there to the summit of Mono Pass the ascent only averages about 200 feet to the mile. It is another day's journey to Lake Mono.

The top of Mono Pass is nearly level for half a mile, about half as wide and gently rounded at the sides. Like the other passes, it is the bed of an old glacier, and remains to-day just about as the glacier left it. A good sized lake occupies the center, along the north side of which the trail runs. When the writer saw it during the latter part of July, the snowfields extended down to the lake both on the north and the south, and the trail was covered to a depth of 8 or 10 feet.

The summit of the pass is just at timber line, as a few scattered white-barked pines bear evidence. They are dwarfed and crushed out of all resemblance to trees by the mass of snow which lies upon them during winter.

A short distance east of the lake, the level stretch comes to an end and the trail enters a deep, dark gorge which plunges downward at so steep an angle as to seem impassable. This gorge is Bloody Canyon, so named because no animal passes up or down the trail which leads through it without receiving wounds on the legs and leaving the sharp rocks stained with blood.

Mono Pass has been used for many years by the Digger and Piute Indians on their way to and from Yosemite Valley and the foot-hills on the western slope, where they made annual journeys to fish and gather acorns. It is now used by white men more than any other pass through the Sierra, because it is the shortest and most direct route between the Mono Region and the California Valley.

15. A DEEP SNOWDRIFT IN MONO PASS

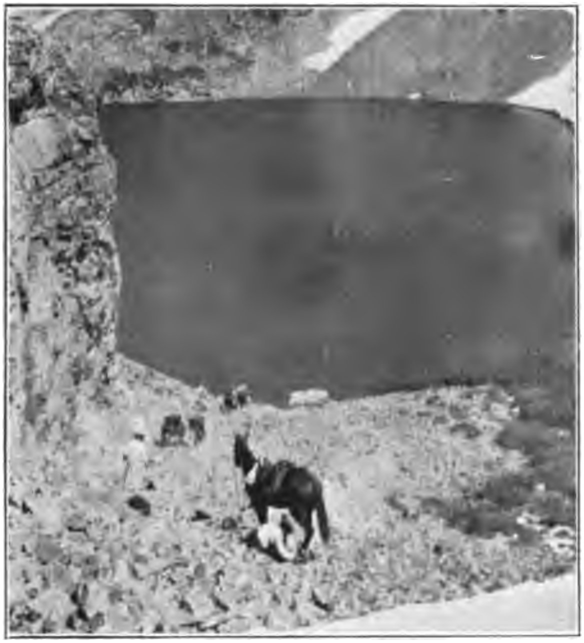
A deep drift, such as this, remains through the entire summer. The trail through the pass goes directly over the drift as there is no way around it on account of the steepness of the sides of the canyon.

The canyon begins with a precipice whose sheer wall of 100 feet or more extends nearly across the pass and seems to block the way. But the trail leads down at the north side over a rocky steep,—a dangerous way where frequently the animals in going down must stiffen their legs and slide. Just below, the canyon is filled with snow from side to side to a depth of some 30 or 40 feet. The trail goes over this snow bank, for there is no way around it. At the foot of the snow there is a deep, dark blue lake, the south half still covered with ice, out on to which a bank of snow extends, hiding the shore.

There is just room enough for the trail between the lake and a high rock wall on the north side. When we get around to the east side of the lake we find that it is held there in the gorge by a dike of harder rock which runs directly across. The stream flowing out of the lake has cut a narrow passage part of the way down through the dike and rushes down the steep below in rapids.

There are several of these lakes, one below the other, none of which fully thaw out until the late summer. The stream flows through them all, and below the last one cuts through a dike, the lower side of which is of such height that beautiful cascades are formed.

In finding a way down the canyon, the trail winds from side to side, crossing the stream a number of times; sometimes it is over glaciated granite with a surface so smooth that it is dangerous to walk upon; sometimes it is over rough, angular blocks of stone, so sharp and jagged that animals in passing stain them with blood from wounds on their legs; sometimes it is over a rock slide where the small loose fragments roll down and completely hide it; sometimes down a zigzag with turns so sharp that an animal almost has to bend its body in passing them.



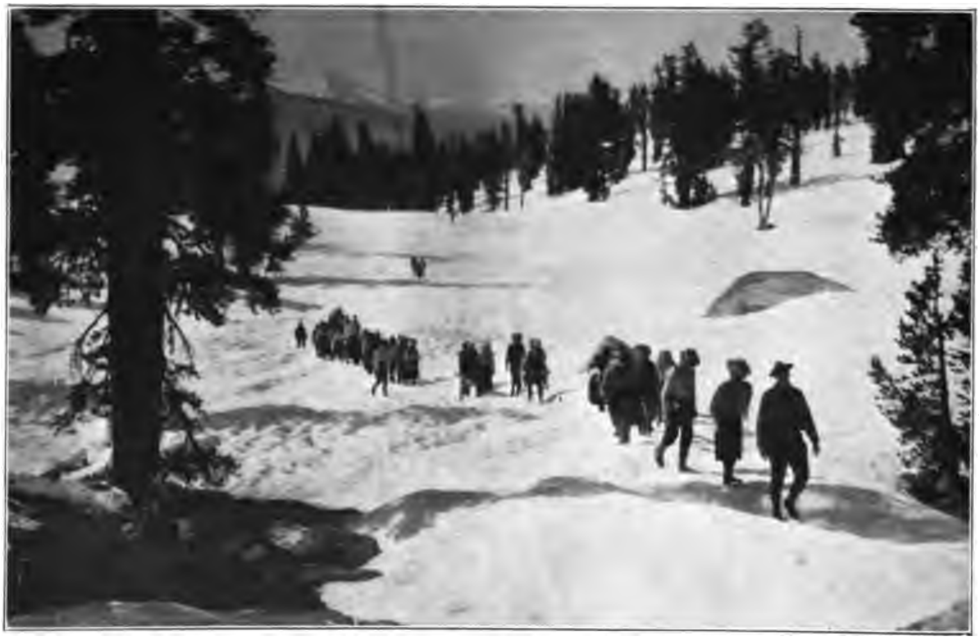
16. ONE OF THE WALLED-IN LAKES OF BLOODY CANYON, ON THE MONO PASS TRAIL.

In the foreground a woman is putting a bandage on the leg of her horse where it has been cut by a sharp, projecting rock.

The steep part of the canyon continues for about 3 miles. Just below where it ends lies Walker Lake, a beautiful sheet of water about a half a mile long and a fourth of a mile wide. This is a moraine lake, the water being held back by a moraine which extends across the lower end.

Although the canyon ends at Walker Lake, yet a deep trough continues out on the Mono plain, made by the high lateral moraines which the old glacier pushed up to a height of several hundred feet.

Where the trail strikes Walker Lake, it meets a wagon road, and from there on the way is through and between the ranches along Walker Creek, the outlet of the lake and from which water is taken to irrigate the fields and pastures. Three or four miles farther on the wagon road begins to branch, and from there roads lead out to all parts of the Mono Valley.



17. SNOWFIELD IN THE UPPER PINE BELT OF THE SIERRA.

This picture was taken about the middle of July. The altitude is a little over 9000 feet. The head of the line of people is just crossing a snow bridge that spans the small stream which shows on the left.

3.

THE SNOWFIELDS.

During the winter time the whole range down to the foot-hills is a glistening field of white. There is very little precipitation during the summer anywhere in California, and both valley and mountain feel the intense heat of the sun; but by the latter part of October or the early part of November the winds from the Pacific bring a load of moisture which is deposited over the valleys and foot-hills as rain, and on the forest belt and the high mountains as snow. The valleys and foot-hills, which during the late summer and fall were yellow and brown, parched from drouth and heat, spring into life and become green, while the forest belt and high mountains are a ridge of white.

One who travels through the forest belt during the winter must tramp over some ten or twelve feet of snow. The trails are all hidden and are only indicated by the blazes high up on the trees. On the high mountains the snow falls to a much greater depth than in the forest belt. Where the Central Pacific Railway crosses the range through Donner Pass, records have been kept which show that more than 30 feet of snow has fallen there during one winter. There is no doubt that on the higher parts of the range farther south as much as 40 or 50 feet fall in some places.

With the coming of spring the melting begins. It goes on rapidly, and the snow line gradually, but steadily creeps up the side of the range. However, it is not until the end of June or early in July that the last of the snow disappears from the forests; and when there has been an extraordinary fall of snow during the winter, the last may not disappear from the forests until August.

In the high mountains much of the snow remains until the late summer, and in some places there are fields several miles in extent which remain from year to year. On the north side of the high peaks there are many perpetual snowfields, some of which merge into glaciers. Some of the higher peaks are surrounded throughout the entire year with snow. Mount Shasta, on account of its more northern position, has more extensive snowfields than any of the other peaks.

18. DEEPLY-PITTED SNOW.
Traveling over such a surface during the middle and after part of the day is very tiresome.

The snowfields on the higher parts of the range, even when they are melting most during the late summer, freeze hard at night, and it is 9 or 10 o'clock in the forenoon before the surface begins to soften to any extent. The surface, on account of the continual thawing and freezing, and the warm winds which blow across them during the after part of the day, become much pitted and ridged, and are very difficult to travel over. In the morning when frozen hard, the ridges are sharp, and this with the deep pits makes walking very difficult. During the afternoon the surface becomes soft, and the walking gets very heavy from dragging the snow. When the steep slopes are frozen, they are very dangerous to climb upon. In going over them in this condition steps have to be cut. Most of the climbing on snow steeps is done after the surface has softened enough that one's feet may find a hold. The descent of the high peaks is frequently made very rapidly by sliding down one of the snow steeps late in the day when the surface is softened.

Many of the snowfields during the summer are of a deep pink color. This "red snow," as it is commonly called, is caused by a very minute vegetable organism which is present in great numbers. When a person walks over red snow late in the day, while the surface is softened, his tracks be-

Photo by Will Boland.

19. COASTING ON A STEEP SNOW SLOPE.

The descent from the summit of a high peak is sometimes made in this way in almost as few minutes as it took hours in going up.

hind him look as if he had been tramping on ripe strawberries which had been thrown onto the snow. This red snow is not over the whole range, but seems to occur without any particular reason as to locality. The writer has seen fields of it almost continuous for five miles.

Throughout the upper part of the forest belt, and higher on the mountains, avalanches are frequent. Sometimes such great masses of snow rush down the slopes that they sweep all before them. Trees several feet in diameter and firmly rooted in the cracks and seams of the granite are torn loose and carried along and piled up in the valleys below. Sometimes huge masses of rock are torn loose and go crashing down with the snow. Not infrequently these avalanches end in a lake which they fill with their debris.

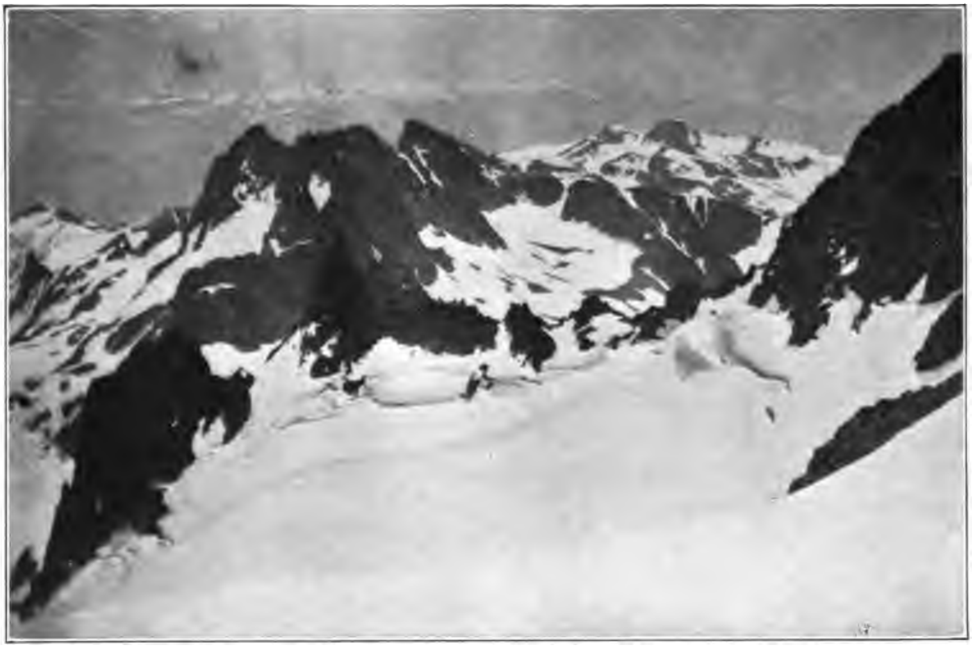
In the higher parts of the range, the rivers are deeply buried beneath the snow during the winter and spring, and rush along their rocky beds entirely hidden from sight, excepting where there are cascades and waterfalls. Even late in the summer, in some of the deep canyons of the high mountains, one can often cross a good-sized stream on a snow bridge.

4.

THE GLACIERS.

The glaciers now remaining on the Sierra are small. There are none much over a square mile in extent. They exhibit very little motion; in fact, many of them seem to have no perceptible motion whatever. John Muir made a close study of the Lyell glacier, one of the largest, and took measurements of the downward motion. He found the movement a little more than 1 inch a day. This is a very slight movement. Many of the glaciers in the Alps move as much as 10 to 12 inches a day, while the Muir glacier in Alaska moves from 5 to 6 feet a day. However, many of these ice-fields in the Sierra, small as they are, exhibit all the characteristics of true glaciers. They have hard, blue ice- fields of granular snow which feed them, bergschrunds, terminal moraines, and milky streams issuing from under the front.

There are probably nearly half a hundred of them, and they are found on the north slope of almost every



20. RITTER GLACIER.

This glacier is one of the deepest in the High Sierra, although its area is not so large as that of some of the others. Note the concentric lines in the foreground, which indicate the direction of motion; also the bergschrunds on the opposite side.

high peak from Mount Dana southward for more than a hundred miles. Some of them are scarcely more than mere fields of hardened snow, which remain from year to year, while others are glaciers of hard, blue ice. They occupy glacial cirques, that is, bowl-like recesses in the solid rock side of the mountain. It is not believed that ordinary ice erosion has entirely formed these cirques. It is much more probable that the vertical seams in the rocks and the freezing and thawing have been the most active agencies.

However these cirques were formed, they have had much to do in producing the sharp divides and the jagged peaks of the High Sierra. Before the

21. LYELL GLACIER.
This is one of the largest in the High Sierra.

snow piled up to such a great depth that it began to pack into the ice which formed the glaciers, there had been a long period of vigorous water erosion, and the range was deeply cut by many water courses. The higher parts were undoubtedly much sculptured, too, and when the ice formed, it naturally moved down the slopes which were already prepared. These slopes were steep, and the movement of the ice must have been rapid. Wherever the ice moved down the slopes of the ridges and peaks, it worked back into the wall of the mountain and formed a cirque. Sometimes two of these cirques formed on the opposite sides of a ridge and worked back toward each other until they met, thus forming a very sharp ridge. Some of the jagged peaks are the result of several cirques working backward toward a common center.

Most of these cirques are empty of glaciers now, excepting where they are on the north side of the mountain. In the bottom of many of the empty ones, however, there is a lake, about which more will be given later.

For the most part, the small existing glaciers lie far back in the bowl of a great cirque, filling only a small part of it. Until along in August the whole surface of many of them is deeply covered with snow, excepting where the wall is too steep for it to stick. Snow-slides and avalanches sometime rush down from the sides, filling up the bottom of the cirque to a depth of a hundred feet or more, and it is often very late in the summer before the glacier ice begins to show at all.

On account of the snow falling for only a few months each year, and that during the winter, the forming of ice from the snow completely stops during the late summer, and as the glacier continues its slow downward

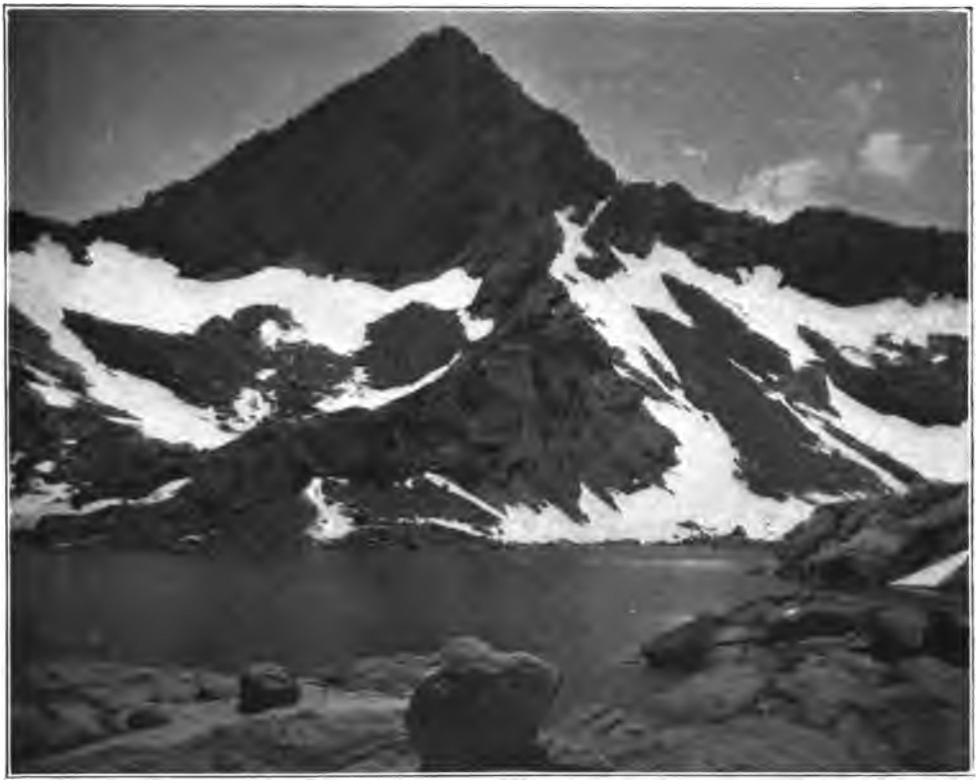
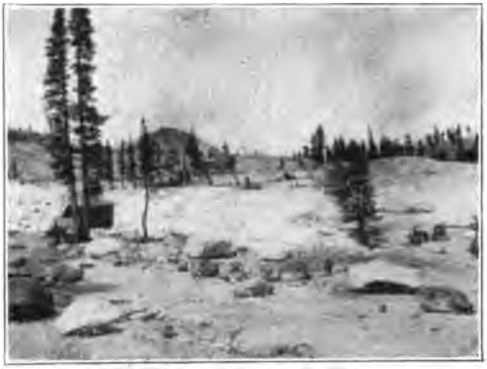


Photo by James Rennie. 22. A SHARP RIDGE BETWEEN TWO CIRQUES.
The sharp mountain peak in the background was formed by these cirques and others on the opposite side of the peak.

movement, it pulls away from the mountain side, opening a gap through the snow which covers the mountain and glacier at that point. This gap is a *bergschrund.* It is seen during the late summer at all the glaciers in the Sierra which have any motion whatever.

The old ice-field of the Sierra was immense. It covered all the higher parts of the range as far south as Mt. Whitney, with the exception of the high peaks, and even they were buried deeply in snow. Glaciers moved down all of the valleys toward the west, descending as low as 3,000 feet above sea level. In a number of cases the ice-field moved down into transverse valleys and up the opposite sides, in some instances ascending 500 feet or more. It covered many of the plateaus which are now within the forest belt. On the east, the ice filled all the short, steep gorges and moved out on to the level floors of the valleys on the border of the Great Basin, piling up high lateral moraines on either side and thus extending the gorges out from the mountain.

The erosion was enormous. All of the loose material was carried away and the softer rocks cut down in some places to a great depth. The ice filled up the old river channels, smoothed off the jagged sides of the canyons and rounded them out, in many cases grinding them much deeper. It moved over many of the lower ridges and peaks and ground them down, or rounded them smoothly off. Some places, on account of the local hardening of the granite, it left great ridges, which, when the ice finally retreated, stood up hundreds of feet above the floors of the valleys and plateaus. At other places, on account of the concentric formation of the granite, it ground out gigantic domes.



23. GLACIATED GRANITE.
Note the bowlders scattered about; also the trees growing in cracks in the granite. There is no soil showing anywhere in the picture.

When the ice finally melted away on the west slope, it must have retreated steadily, for it left nowhere any great terminal moraines, to show where it halted for any great length of time. The retreating must have been somewhat rapid too, for it has left very little material excepting the boulders that lie scattered everywhere. On the eastern slope, on account of its steepness, the ice did not retreat so rapidly, and there are terminal moraines almost everywhere at the opening of the

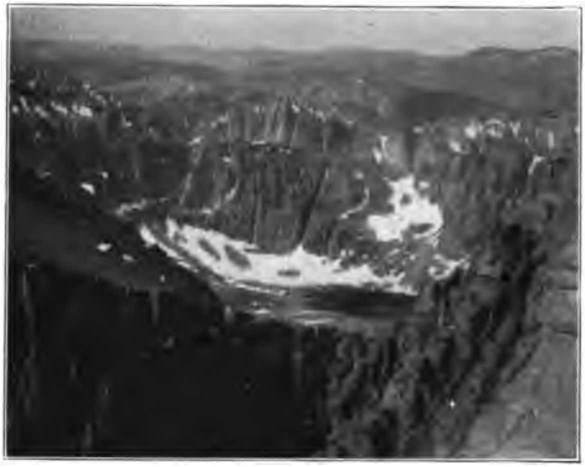


Photo by James Rennie.
24. LAKE IN OLD GLACIAL CIRQUE.

canyons, and even within the canyons themselves.

When the glacier finally melted away, it left the range a glare of bare granite, having the surface as highly polished as a mirror, with very little debris of any kind hiding it, excepting the boulders before mentioned. For all the thousands of years which have passed since the glacier left it, this polished surface remains today in many places; and where there is any considerable slope, it is dangerous to walk upon.

5.

THE LAKES.

There are thousands of lakes in the High Sierra. With very few exceptions, they owe their existence to the old glaciers. It has already been mentioned that they are found in many of the cirques. These of course lie in a rock bowl which the glaciers scooped out, or else are held back by moraines across the cirque.

In many of the canyons leading down from the high mountains there is a string of lakes,—sometimes con-

Photo by James Rennie.

25. GLACIAL LAKES IN A CANYON.
The two lower of a chain of lakes.

sisting of as many as half a dozen. The lower ones of such a series are in most cases moraine lakes. They are usually not so deep as those further up the canyons, which occupy rock basins that the glacier has ground out. These rock basins are frequently behind dikes of hardened rock which run across the canyon and which the glacier was not able to wear away. The lakes of such a canyon are usually connected by a stream, which flows over the rock obstruction at the lower end of the lake in falls or cascades. Where the stream cuts through the moraines which hold back the lower lakes, there are usually rapids.

The glacial lakes are wonderfully clear and of an intense blue color. When they are very deep, as many of them are, the color is an indigo. Many of them are at an altitude of 10,000 to 12,000 feet. None in these high altitudes thaw out until late in June, and many not until August or September. The first sign of their thawing out is usually a ring of greenish blue around the north margin. This shows where the water is finding its way through the deep snow above, the snow

26. A SNOW COVERED LAKE IN AUGUST.
The lake is in the lower right hand corner of the picture. Its outline is just beginning to show.

27. MIRROR LAKE. YOSEMITE VALLEY.

melting at the surface and gradually sinking with the increasing heat of the season. This ring of greenish blue changes from day to day to a darker blue, as the snow continues to melt. Sometimes it is two or three weeks after the first signs of color before the snow and ice disappear and the clear water of the lake shows.

Some of the wide glacier valleys are

28. LAKE MONO FROM THE SUMMIT OF MT. DANA.
The lake appears indistinct on account of the haze which is over the desert.

thickly sprinkled with lakelets which occupy flat depressions ground out in the rock floor by the old glacier. During midsummer, when the snow is melting rapidly, some of these mountain basins look like one big lake with many islands and intersecting rock ridges. As the season advances the snow disappears and the basin looks what it really is, a flat floor with many small lakes scattered about. These mountain lakes are all fresh, although many of them during the late summer have no outlet; yet in early summer when the snow is melting, the lakes all overflow, so the water is kept fresh from year to year.

Many of the mountain lakes are of wonderful beauty. In early morning before the wind rises and ruffles the surface of the water, they reflect the surrounding scenery as perfectly as a mirror. Looking across such a lake you may see a mountain peak towering in the sky and its exact counterpart inverted in the lake, the image having every feature as clear and distinct as the real mountain above. Or, if the lake is bordered with pines, as some of them are, the reflection of the trees looks like a giant fringe of dark green hanging in blue space, every bough and needle of the pines standing out distinctly. Whether it is mountain or forest that is mirrored by the lake, the background of the sky seems deeper, clearer and bluer in the reflection than in the real vault above.

While all the mountain lakes of the Sierra are fresh, there are a number of salt lakes which owe their existence to the snow which falls on the top of the range. These lakes lie at the foot of the eastern slope in the edge of the Great Basin. They have no outlets, and if it were not for the streams coming down from the mountain snows, which feed them, would speedily dry up and leave deposits of salt and other minerals. The largest of these salt lakes are Mono and Owens. Mono Lake lies about 30 miles east of the Yosemite Valley, and Owens Lake a few miles southeast of Mt. Whitney.

29. KERN CANYON.
This canyon is from 2000 to 2500 feet deep and extends for 30 miles in nearly a straight line.

6.

THE RIVERS, WATERFALLS AND CANYONS.

The western slope of the Sierra is intersected by numerous rivers that occur at somewhat regular intervals of from 20 to 30 miles. With the exception of the Kern, all flow in nearly a straight course from the top of the range to the California Valley.

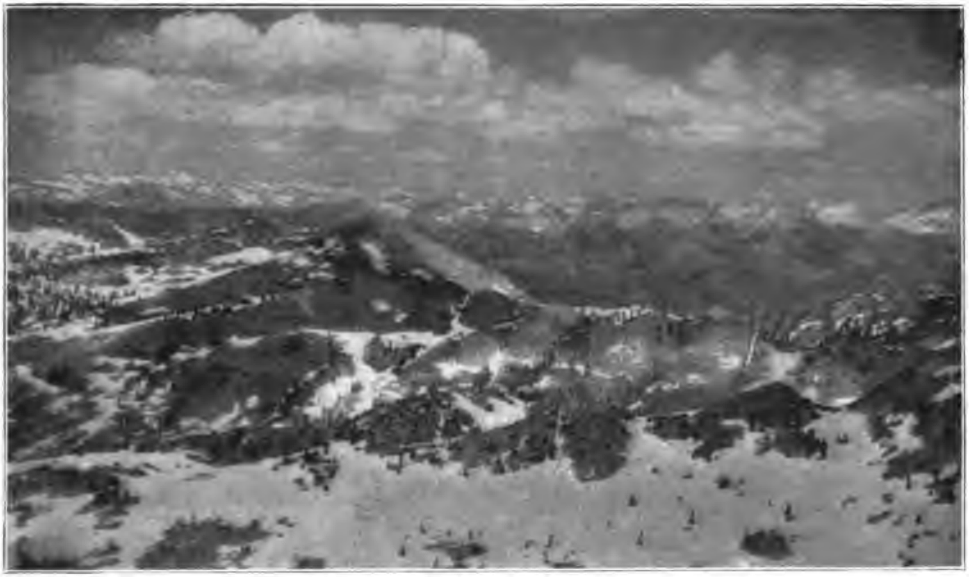
The Kern is the most southern of them. Going north we cross in order the Tule, Keweah, Kings, Upper San Joaquin, Merced, Tuolumne, Stanislaus and American. They all rise in the snowfields among the high peaks of the Main Divide. Through the High Sierra, the forest belt and the foot-hills, they are noble mountain streams; but when they reach the level floor of the dry, sandy valley they become sluggish, and dwindle away from evaporation and from the sinking of the water into their sandy beds. Also, much of the water is now taken out of their channels along in the foothills and carried in ditches to the level lands of the valley for irrigating purposes.

In the spring and early summer when the snow is melting very fast, the rivers are swollen torrents and are dangerous to ford. During the late summer and in the fall when the snow is nearly melted, they dwindle to much smaller streams and occupy but a narrow part of their rocky beds.

The valleys they occupy were the channels of streams before the old glacier covered the range; but as already mentioned, the ice stream very much changed the valleys by widening and deepening them, smoothing off the jagged sides of the gorges and everywhere leaving a polished surface of bare granite.

Since the rivers again took possession of their old beds, which was as soon as the ice melted away, they have scarcely worn any channels at all, and in many places, especially in the higher parts of the range, are flowing over the hard, bare granite without apparent banks to retain them.

In midsummer it is interesting to go to the sources of the rivers in the High Sierra. Early in the morning the snowfields are frozen hard, no breeze is stirring and there is absolute silence everywhere. As the sun rises, a breeze springs up. By 8 or 9 o'clock the surface of the snow begins to soften and soon silver threads of water steal away from the lower edge of the snowfields and glide down the slopes. Almost immediately several of them unite, and if you listen closely, you will hear the little rill softly murmuring to itself, as if glad to get away from the cold embrace of the snow. As the day advances, the melting goes on more rapidly and the water drains away from the edge of the snowfields in an almost continuous sheet. Collecting into rivulets, it rushes down the slopes in rapids and drops over rock ledges in falls and cascades, and everywhere you may hear the rush of water as it hurries away to seek the larger stream below. Several of the larger rivulets unite and form a creek, which in turn unites with



30. TUOLUMNE CANYON FROM MT. HOFFMANN.

The view is a little west of north and shows the canyon running from the crest of the Main Divide toward the California Valley.

other creeks and the stream becomes large enough to be called a river.

Nearly all the rivers have along their middle courses tremendous canyons. They are of a type which may be said to be peculiar to the Sierra, and sometimes they are referred to as the Sierran type of canyon-sculpture. Many of them are profoundly deep and have flat floors and nearly perpendicular walls. They are largely in the forest belt, and frequently their floors are well wooded, while the timber ot the bordering plateaus extend to the very rim of the towering walls.

Yosemite Valley is the best known and in many ways the greatest of them all. It is considered the most typical, and its name is used to indicate the other Sierra canyons of the same kind. Thus we speak of the yosemite of the San Joaquin, the Kings River yosemite, or the yosemites of the Sierra, meaning in every case canyons of the same form as the Yosemite.

In many of the yosemites there are wonderful waterfalls. The river which flows through the canyon sometimes drops into the gorge in a series of high falls and cascades. But the highest and most beautiful are those of the tributary streams which come in from the bordering plateaus and fall into the canyon over its high, perpendicular walls. A number of the yosemites have several of these falls from tributary streams. In the spring and early summer when the snows of the forest belt are melting rapidly, these falls have a vast amount of water and are not surpassed in beauty anywhere in the world. Some of them are a thousand feet or more in vertical height. As the summer advances and the snows of the forest belt disappear, these falls dwindle away and in many cases entirely stop until winter comes again.

In some of the canyons there are two or three yosemites one after the other. The upper one is usually at a considerably higher altitude than the one next below, while the river between the two is much broken by falls and cascades. The lower yosemite is always much the deeper and its walls are more nearly perpendicular.

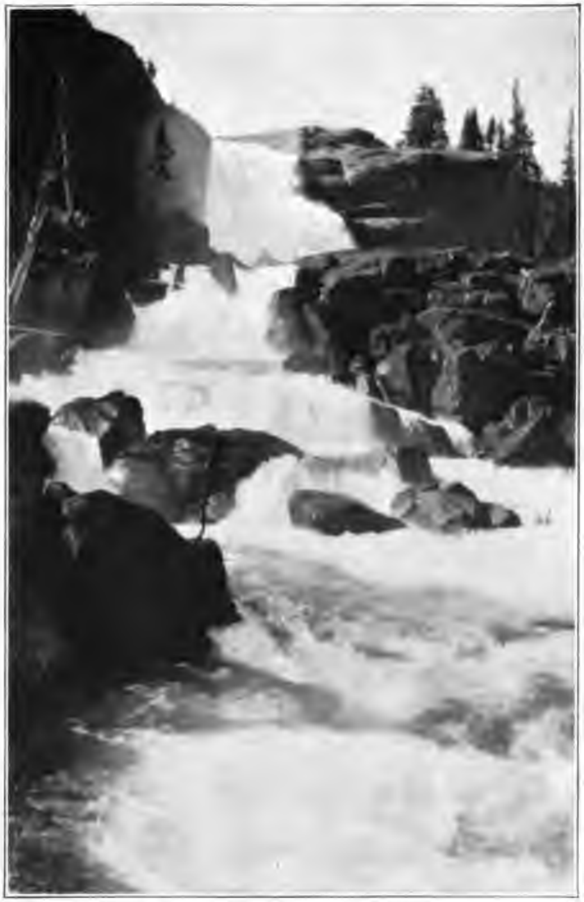
Below the yosemites the canyons show less and less the erosion effects of the old glacier, and more and more the work of running water and general disintegration. In the upper part of the foothills the rivers are still swift with many rapids, and their gorges deep. But for the most part the gorges are so sharply V-shaped that the streams occupy the entire width at the bottom. Through the lower foothills the canyons widen again, the high walls drop away and the river valleys gradually open out into the greater California Valley.

A better idea of these rivers and their gorges will be gained from a closer study of some one of them. For this purpose the Yosemite Valley is chosen.

7.

YOSEMITE VALLEY.

The Yosemite Valley is situated on the western slope of the Sierra Nevada mountains, about 150 miles nearly due east of San Francisco. It



31. GRAND FALLS OF THE TUOLUMNE.

Note the difference between this fall and that of Yosemite Here as the river plunges from ledge to ledge, it seems to be rushing down a giant stairway.

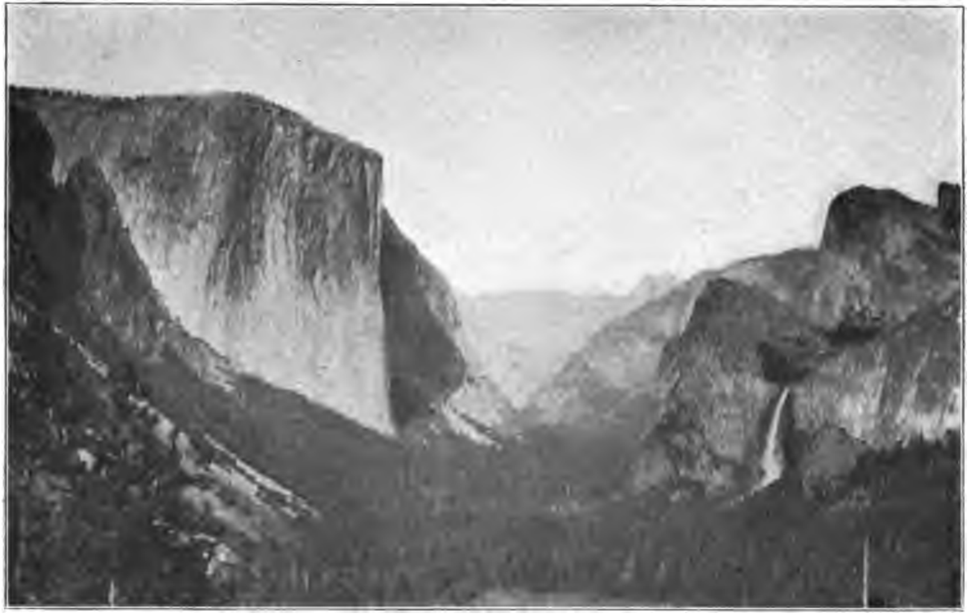


Photo. by R. T. Jones. 32. YOSEMITE.

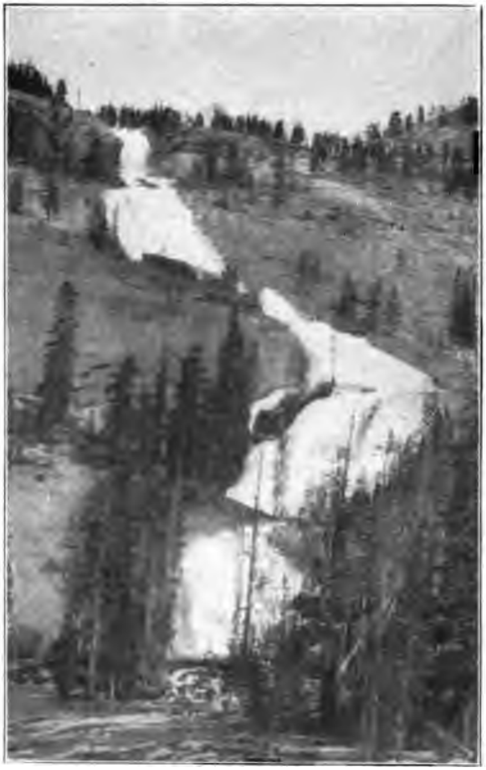
Looking into the Valley from the lower end. El Capitan, 3200 feet high, shows on the left, and Bridal Veil Falls, 900 feet high, on the right.

forms part of the general valley of the Merced River, which rises on the summit of the range and flows westerly to the San Joaquin River.

The Merced is formed by streams which rise on the south slopes of Mt. Lyell and Mt. McClure, and neighboring peaks, and on the north slope of Mt. Merced, the Triple Peaks, and other peaks which lie some 20 miles south of McClure. These streams unite to form the Merced about 20 miles east of Yosemite Valley. All of them are fed by perpetual snowfields, and for the few miles of their course are a series of waterfalls, rapids and cascades. The most important of these tributaries are Foerster's Creek, and Triple Peak Fork. The Merced River properly begins where these two unite; its gorge may also be said to begin at this point; for these creeks, just before their juncture, drop from the heights above in a series of cascades fully 1500 feet.

From where the Merced River is formed by the union of Foerster's Creek and Triple Peak Fork to where it emerges from the foothills on to the San Joaquin Valley, a distance of more than a 100 miles, it is almost a continuous series of rapids and cascades, with here and there waterfalls of tremendous height. The longest stretch of quiet water it presents is in the Yosemite Valley, whose level floor permits it to have several miles of gentler, more unruffled flow.

The Merced after its origin at the confluence of Foerster's Creek and Triple Peak Fork, gathers rapidly in volume, receiving streams from either side at short intervals for perhaps 6 or 8 miles. Its valley is narrow and increases rapidly in depth. The river itself is almost a succession of rapids, except where it rests in Lake Washburn for half a mile and in Lake Merced for perhaps a mile. These two lakes are beautiful sheets of quiet water, which reflect back the mountains and overhanging cliffs with the vividness of a mirror.



33. FALLS OF TRIPLE PEAK FORK.

The Merced river begins at the foot of the falls. The water has been flowing over the hard, glaciated granite for thousands of years, yet the stream has not cut a channel deep enough to form banks.

Below Lake Merced the river flows through a little valley, known as Lost

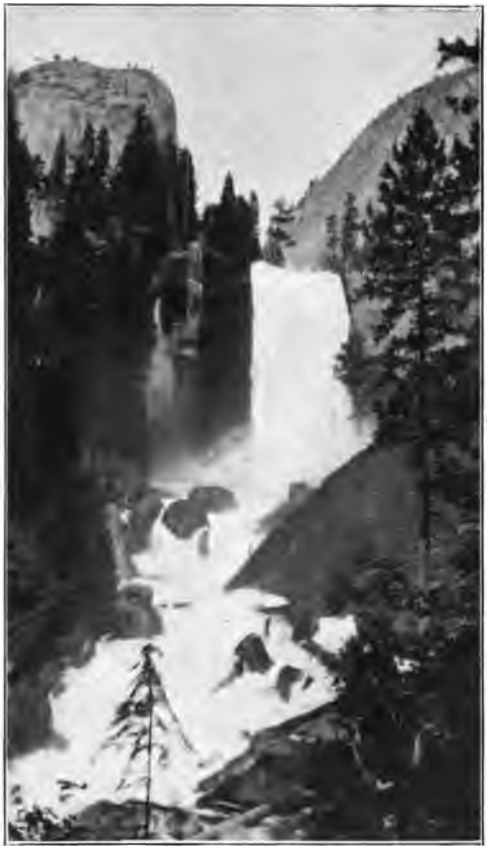


Photo by S. H. Thomas.
34. THE MERCED AT VERNAL FALLS, JUST ABOVE THE YOSEMITE.
The height of Vernal Falls is 350 feet.

Valley on account of its inaccessibleness, which is a type on a very small scale of the Yosemite Valley itself. From Lost Valley the river plunges through an impassable gorge for a mile or two, from which it emerges into the Little Yosemite.

The Little Yosemite Valley is about five miles long and is in many ways a duplication of the greater Yosemite. Its walls do not rise so high and are not nearly so perpendicular. Neither is the floor uniformly level, but in many respects it bears the features of the greater valley. The floor of the Little Yosemite lies some 2,500 feet above that of the greater Yosemite, and the Merced River within a distance of four or five miles drops down this altitude, forming waterfalls of hundreds of feet in height, and long series of rapids and cascades.

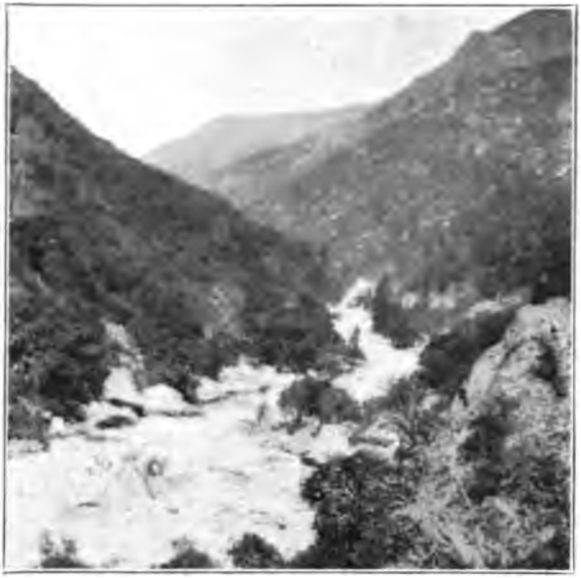
The Little Yosemite may be said to end at Nevada Falls, which have a sheer drop of 600 feet. From the foot of Nevada Falls the Merced dashes and foams in one continuous series of rapids for nearly a mile to the top of Vernal Falls, where it makes another perpendicular drop of about 350 feet, then again rushes on its way in continuous rapids and cascades. About three miles below Vernal Falls it reaches the main floor of the Yosemite, along which it flows in a meandering course for seven or eight miles, in many places a tranquil and placid stream.

Photo by R. T. Jones. 35. THE MERCED IN THE YOSEMITE VALLEY.

In many places along the 6 or 8 miles of its course through the Yosemite the river loses its swiftness, widens out and presents a surface almost smooth enough for reflections.

The Yosemite Valley is sometimes considered as beginning where the Merced River makes a 600 foot drop at Nevada Falls; but the four miles of the river gorge immediately below this point is very rugged, and differs from the main part of the valley in being partly V-shaped and in not having a level floor. So the valley may properly be said to begin where the Merced River ceases its mad plunges and enters its course over the level floor.

At the head of the valley, about where the Merced begins to flow more quietly, Tenaya Creek comes in from the east, the walls of its canyon for some distance back being as high and perpendicular as those of the Yosemite itself. Mirror Lake, one of the attractions of the Yosemite so frequently illustrated, is in Tenaya Canyon.



36. THE MERCED IN THE UPPER PART OF THE FOOT-HILLS.

Note the somewhat sharply V-shaped gorge, showing the absence of glacial action. The swift stream in the picture is a good example of what the river is like for much of its course through the upper foot-hills.

The Yosemite Valley is about seven miles long and from one-half to one mile wide. From the upper end the general direction is northwest for about two and one-half miles, when it turns a rather sharp angle toward the southwest. After pursuing a southwesterly direction for another two and one-half miles, the course changes to nearly due west. At the lower end there is no abrupt termination as at the upper end, the valley gradually assuming the shape and general characteristics of a V-shaped river gorge, and the Merced again becoming a foaming, turbulent stream.

The walls rise in many places nearly perpendicular to a height equaling that of the width of the valley. The bottom is so nearly level that when viewed from some point of vantage on the rim it looks like the floor of a gigantic hall. There is considerable talus along the sides of the gorge, yet the slopes of rock waste look small, on account of the immense height of the bordering walls.

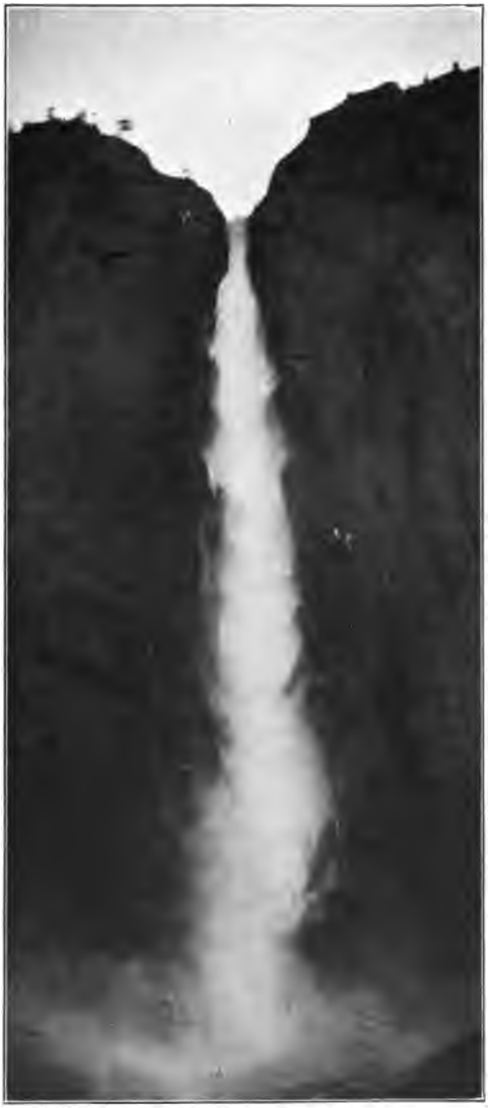
Everywhere scattered over the floor of the valley, but more particularly near the sides, are great angular blocks of rock that have fallen from the cliffs above. These blocks do not show much weathering, thus indicating that they are of recent origin. The banks of talus at the foot of the cliffs are composed largely of angular material, showing that they, too, are recent and are now in the process of accumulation.

The floor of the valley is covered with a fine forest composed largely of firs, yellow pines, sugar pines and other evergreens. Many of the pines are from four to six feet in diameter and 200 feet in height, and are truly magnificent. There are no giant sequoias, the nearest grove of these great trees being about fifteen miles away. There are also groves of fine oak trees, through some of which a carriage road runs, presenting the appearance of a beautiful, shaded avenue. These oaks are not large, seldom exceeding two feet in diameter. There are a few small natural meadows scattered along the course of the Merced, which, when seen from some point of vantage on the rim of the gorge, look like little garden patches. Some of these meadows contain small lakes which are such perfect mirrors, that when looking across them, one sees forest and mountains duplicated with startling vividness.

Ferns, flowers, and grasses everywhere abound, even in much of the forest, which is open enough to allow of their luxuriant growth.

Besides the two gorges, the one of the Merced and the other of Tenaya Creek, at the head of the valley, there are a number of small tributary gorges; but they are either sharp and abrupt, or else open out through the bordering cliffs at high altitudes. Through all of these gorges flow tributary streams, which, when they reach the side of the valley, either drop in perpendicular falls, or jump in a series of cascades to the floor of the valley and unite their waters with those of the Merced. Some of the waterfalls thus formed are among the highest in the world. The falls of Yosemite Creek have a total drop of 2,600 feet, composed of two parts, known as the Upper Yosemite and Lower Yosemite Falls. The Upper Yosemite Falls have an unbroken descent of 1,500 feet. The stream then cascades for a short distance and drops the remaining part of the 2,600 feet in the lower falls. When viewed from across the valley the Upper Yosemite Falls look like a thin, silver column against the dark, towering wall.

The Nevada and Vernal Falls have already been spoken of in connection with the gorge of the Merced just above the Yosemite Valley. They are both magnificent falls, the Nevada Falls ranking as one of the great falls of our country. The whole volume of the Merced River here drops in an unbroken sheet a distance of 600 feet. The mass of water is sufficiently great, that while much of it is dashed to mist and spray which the wind carries hundreds of yards distant, and sometimes makes the whole immediate vicinity seem to be enveloped in fog, yet the sheet of water appears to remain unbroken until it strikes the rocks beneath.



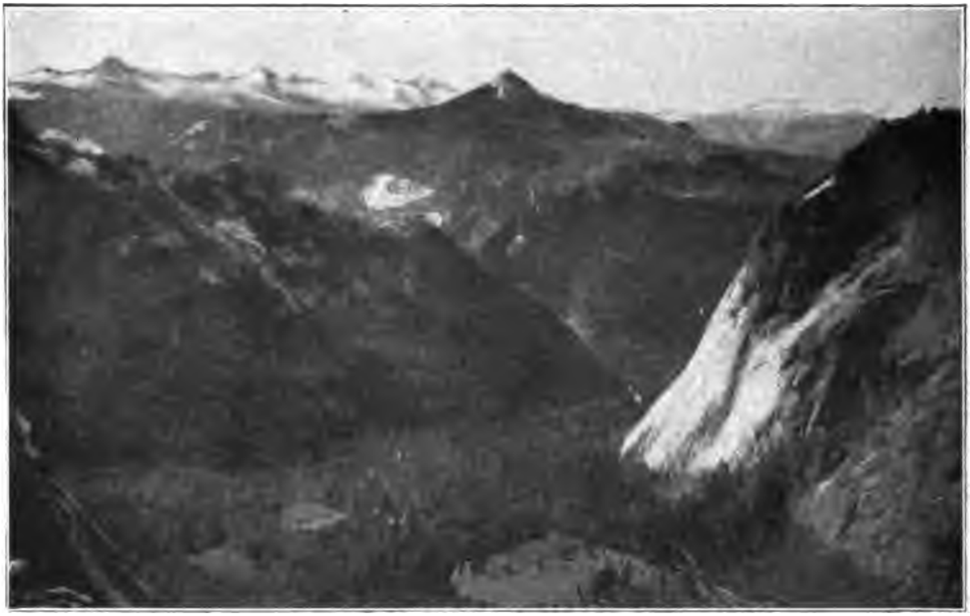
37. UPPER YOSEMITE FALLS.
Height 1500 feet.
The falls are caused by a tributary stream, Yosemite Creek, flowing over the perpendicular wall from the bordering plateau.

Other falls of the valley are the Bridal Veil Falls, with a sheer drop of 900 feet, the Cascades, Illilouette Falls, Vernal Falls and Ribbon Falls. In the early spring, at the time of the melting of the snows, there are many other small falls and cascades which dry up as the summer advances.

Among the prominent features of the valley and vicinity are the great rounded domes which loom up here and there on the top of the bordering walls. The most prominent of these are the North and South Domes which tower up on opposite sides of Tenaya Creek gorge just where it unites with Yosemite Valley, the Sentinal Dome and Liberty Cap. Domes of this character are found at other places in this region of the Sierra. They owe their origin to the concentric formation of the granite and to the grinding power of the glaciers which at one time moved over them.

There has been much discussion concerning the origin of the Yosemite Valley. Some scientists have held that its level floor and perpendicular walls could only have come through some vast earthquake disturbance, when a great block of the earth's crust was bodily displaced and shoved downward. But those who have held this theory have admitted that after the valley was thus formed, it was subjected to a long period of erosion and glacial action.

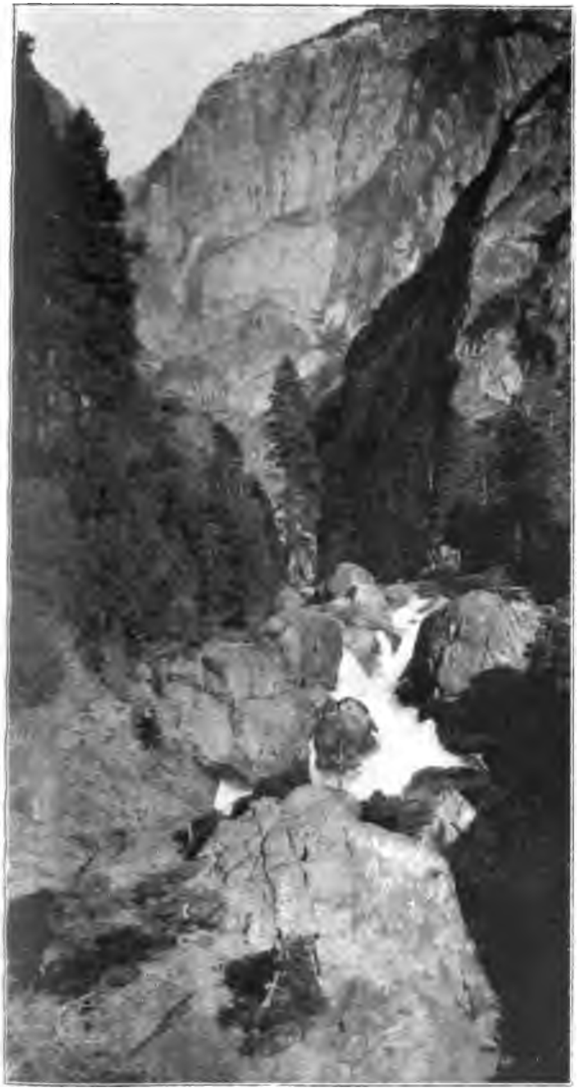
There appears to be little foundation for the earthquake theory. It seems probable that the great trough was cut out entirely by river and glacier. It is not improbable, however, that the direction was guided by previous earthquake movement, and even that the sides of the gorge may be along the lines of extensive earthquake fissures. Those who have opposed the theory of glacial origin have contended that there is no evidence of such extensive glacial work; and indeed there is no great amount of morainic material and glacial debris in sight, either in the valley or along the Merced River immediately below. But this can easily be accounted for. The whole western slope of the Sierra throughout this region has been strenuously glaciated, and yet there are a few great accumulations of morainic material. This is due perhaps to the rapid retreat of the ice-fields when it once began to melt away.



38. LOOKING DOWN INTO YOSEMITE VALLEY FROM THE TOP OF YOSEMITE FALLS.
Note the flat floor of the valley.

However, there are moraines along the gorge of the Merced and on the floor of the Yosemite Valley itself. But in the gorge of the Merced they have largely been carried away, and on the floor of the Yosemite Valley have been covered by the accumulation of soil and by forests of centuries' growth.

For a long time the Yosemite Valley was maintained as a state park, but recently the state turned it over to the national government and it now forms part of the Yosemite National Park, which includes a region of the Sierra about 30 miles square. For many years there have been carriage roads leading into the valley, and the place has been visited annually by thousands of tourists. But the trip has required



39. MUIR GORGE IN THE TUOLUMNE CANYON.
This gorge is impassable.

a stage ride of more than 100 miles for the round trip, which prevented many people from going. Recently, however, a railroad has been completed to within ten or twelve miles of the valley, thus making it more accessible.

On account of the abrupt walls and the steep, high climbs that have to be made in order to reach many of the points of interest, travel about the valley has to be afoot, or on horseback. Numerous trails have been built and others are constantly being constructed. They are kept in good repair and rendered as safe as possible. These trails lead to the higher points of vantage and in many cases wind up gorges by the side of towering falls.

Among the other gorges of the Sierra there are several which vie with the Yosemite in grandeur and beauty. Probably the finest of them are the Hetch Hetchy Valley on the Tuolumne River, Kings River Canyon and Kern Canyon.

8.

FORESTS.

In climbing any mountain you will notice that the character of the vegetation constantly changes. Very few plants extend for more than 5,000 feet in vertical height, and most of them have a range much less than that. So in going up a high mountain, you will find from time to time new species coming into view, and that those which were common lower down are disappearing, or are altogether absent. You cannot help but notice, too, that the plants of the same species change, the higher you go. You will notice this more particularly with the trees, because being larger, their changes are more easily seen. For instance, a pine which grows to a height of 150 feet at its best, 3,000 feet higher in altitude would probably be less than 100 feet high and not so perfectly formed.

Thus mountains limit the distribution of plants by presenting a high barrier, over which they cannot spread. Valleys may do the same thing, on account of being at too low an altitude. Thus the California Valley, which separates the Coast Range from the Sierra Nevada, is too low and dry for the vegetation of either range to flourish, so the trees of the two ranges are almost totally different. The two or three species of trees which are found on both have probably spread around the northern end of the valley where the two ranges blend, keeping at about the same altitude.

This limitation of plant life by altitude is an interesting study. To see how low down on a mountain slope a certain tree appears; to find where it grows to its largest size and has its most perfect development; to watch for the highest point where it will possibly grow, and note there its dwarfed and inferior appearance, all combine to make the study of that tree more intense than were it a tree of the plains.

Limitation of plant life by altitude causes the different species to appear in belts or zones, extending along the mountain slope for long distances, sometimes hundreds of miles, but the width of which is determined by the steepness of the slope. In the Sierra Nevada these belts extend practically

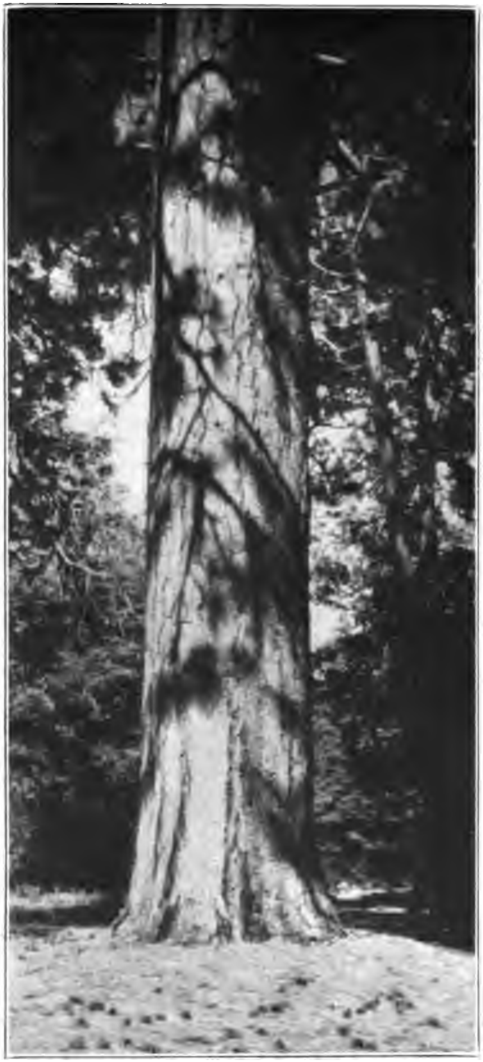
40. FOREST OF THE MAIN PINE BELT.

This picture shows the forest of the Main Pine Belt bordering a small mountain meadow. The trees are Yellow and Sugar Pines, Incense Cedars and Giant Sequoias.

the whole length of the range, but the width is seldom more than 25 or 30 miles.

In ascending a mountain, so regularly does the vegetation change that any person who is at all accustomed to mountaineering can judge very closely the altitude by merely observing the trees. This is especially true of the Sierra Nevada. So regularly do the different species of trees succeed each other that the altitude can almost unerringly be determined from them. Thus the forests of the Sierra afford an opportunity to study to the very best advantage the distribution of plant life as affected by altitude.

Starting up the western slope from the treeless California Valley, we first come to the foot-hills, where there is



41. TRUNK OF A YELLOW PINE.

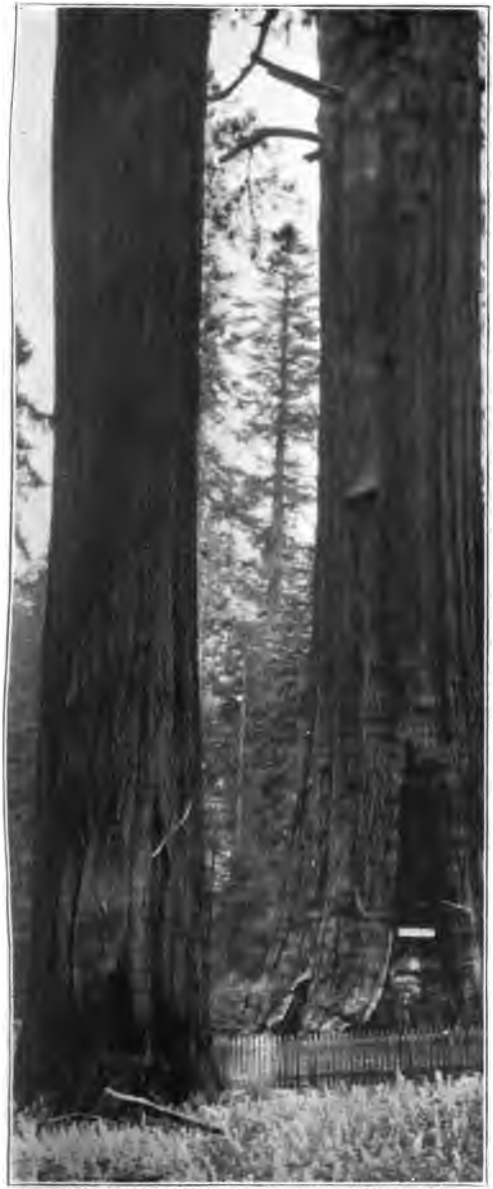
This tree is about 8 feet in diameter and 200 feet in height. Note the large plates into which the outside of the bark is divided.

only a mere fringe of forest, made up of small oaks and pines. These, too, are not numerous, and during the heat of the day they furnish shade for a very small portion of the ground. Moreover, their foliage is thin and scant, so that during the long summer months the surface of the ground everywhere is parched and dry.

As we ascend the foot-hills, we soon come to the Chaparral, a growth of low bushes made up mostly of manzinita and ceanothus, and which frequently is so dense as to make traveling difficult. The wood of these bushes is hard, almost bony, and very tough. Sparsely scattered in the chaparral are small oak trees and two species of pines, the Nut Pine and Hickory Pine, both rather small trees not over 60 to 75 feet high and a foot or two in diameter, and with very thin foliage.

Fifteen or twenty miles from the lower edge of the foot-hills, at an altitude of from 2,000 to 3,000 feet, we pass into the Main Pine Belt. Here are found the Sugar Pine, Yellow Pine, Incense Cedar, Douglas Fir and Sequoia. These are all great trees and comprise the finest coniferous forest in the world. The Yellow Pine when full grown is some 5 to 8 feet in diameter and from 150 to 200 feet high. The bark is a yellowish brown and marked off into great plates, irregularly fashioned, somewhat like an alligator's skin. The cones are large, running from 6 to 10 inches long and from 2 to 4 inches thick. The Sugar Pine is from 5 to 8 feet in diameter and from 200 to 250 feet high. This is one of the most majestic of all the coniferous trees and in many ways the most beautiful. Its bark is much closer than that of the Yellow Pine and vertically ribbed. It bears gigantic cones which reach a length of from 12 to 15 inches and a weight of several pounds. The Incense Cedar is from 5 to 8 feet in diameter and from 150 to 160 feet in height. This tree is noted for its fragrant foliage, the needles often being gathered to make pillows and cushions.

The Sequoias are the largest trees in the world. When full grown they measure from 20 to 30 feet in diameter and from 250 to 300 feet in height. They probably live to a greater age, too, than any other trees in the world, some of them reaching an age of four thousand years. The bark of the Sequoia is extremely thick, sometimes reaching 20 inches, and

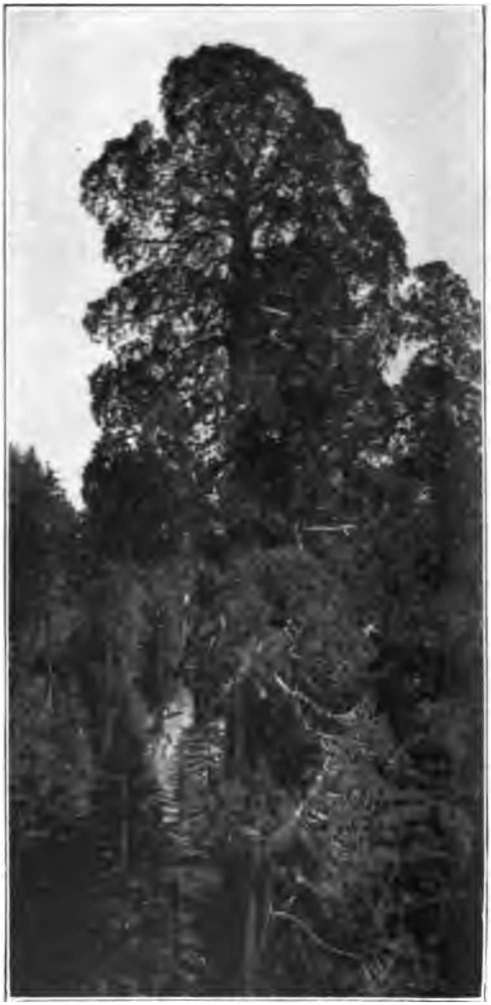


42. TRUNKS OF TWO GIANT SEQUOIAS.

The Giant Sequoias are very difficult to get photographs of complete, on account of their great height and being generally surrounded by other trees. The tree on the right of the picture is known as "General Sherman." It is nearly 30 feet in diameter and about 300 feet in height. Some idea of its great size may be gathered by comparing it with the surrounding fence, or the figure of the man standing close beside it. Note the great scar extending up from the base 25 or 30 feet, which has been caused by fire. The tree on the left is much younger and does not show any effects from fire.

serves to protect the tree from the destructive fires which sometimes devastate the Sierra forests. Indeed, it is wholly due to the armor of bark that so many of the giant trees have reached such a great age and grown to such immense size; for at various times during the life of those which are more than a thousand years old, the surrounding forest has been totally destroyed by fire. The cones of the Sequoia are very small, ranging from 1½ to 2 inches long and from 1 to 1½ inches in diameter. It seems strange that these greatest of all trees should have such very small cones.

The world contains no forest more beautiful than that of the Main Pine Belt. There is little or no underbush and the trees rise like towering columns, the trunks often free of limbs for a hundred feet and free of mar or blemish. High above, the tops touch one another and form a canopy of dark green, the whole reminding one of an immense temple where the roof is supported by a myriad of pillars. Travel afoot or on horseback is unhampered, and in many places the timber is open enough to allow of driving about freely. Some of the very finest parts of this forest lie just north and



43. TOP OF A TYPICAL SEQUOIA.

About 50 feet of the lower part of the trunk of this tree does not show in the picture. Note how few limbs there are until near the top; also their immense size and apparently great strength. This tree shows the dome-like shape of the top peculiar to the Giant Sequoias.

Photo by R. T. Jones.

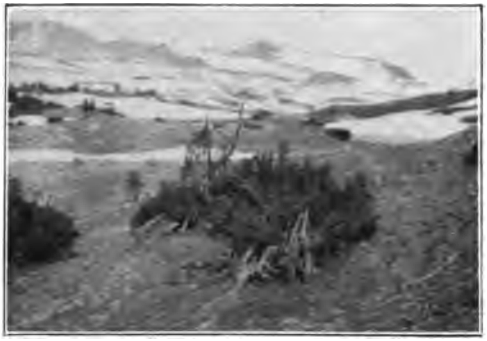
44. FOREST IN THE SILVER FIR BELT.

Note that this forest is denser than that of the Main Pine Belt, and the trees more slender.

south of the Yosemite, and the stage roads leading into the famous valley pass through them.

The Main Pine Belt extends up to over 6,000 feet in altitude, merging gradually into the Silver Fir Belt, where the forest is more dense, yet open enough for traveling almost anywhere. The firs of this belt are tall, fine trees, averaging, when full grown, from 175 to 225 feet in height.

Between 8,000 and 9,000 feet above the sea the Fir Belt merges into the Upper Pine Belt, where are found the Tamarack Pine, Foxtail Pine and Hemlock Spruce, all of which are much smaller trees than those of the lower belts, and for the most part not so perfect. Their trunks are frequently scarred from rock slides and avalanches, and the boughs broken from the great weight of the winter snows. The tallest of them are not much over 50 or 60 feet, with the trunks large near the base and tapering rapidly toward the top. The trees of the upper pine belt do not form a continual forest. They are found on the slopes of the ridges and on the floors of the valleys where the soil has collected. For the most part the tops of the ridges and the steep rock slopes are bare. The trees extend up to timber line, becoming more and more



45. TAMARACK PINES ON MONO PASS.

Altitude 10,600 feet. Note how these pines are dwarfed by the high altitude and crushed all out of shape by the great masses of snow which cover them during winter.

dwarfed, until the very last found are but a few feet in height and frequently without any real trunks.

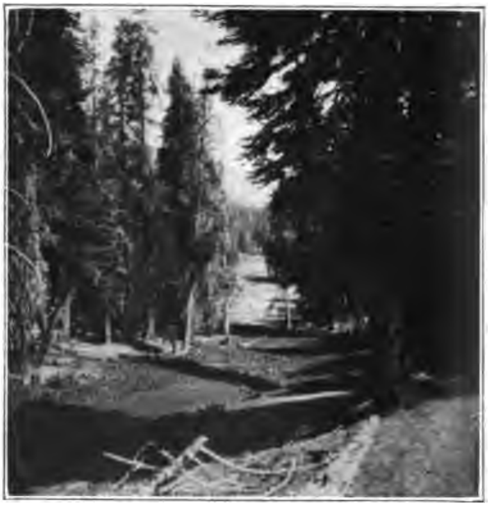
The juniper, or red cedar, is somewhat common on the steep, rocky slopes of the upper pine belt, where it grows to the enormous thickness of from 6 to 10 feet; but the trees are much scarred and broken and are so decayed that they are of no use whatever for lumber.

9.

MOUNTAIN MEADOWS.

From 7,500 to 10,000 feet above sea, scattered here and there in the Fir Belt and on well up through the Upper Pine Belt, are found the Mountain Meadows. In the Fir Belt they are nearly always closely surrounded by the forest. Farther up they are more open, although it is nothing unusual to find them bordered with tamarack pines; but the pine forest is more open and the meadows there much larger.

The lower meadows are usually small, often not containing more than an acre or two. Many of them which are found in the giant sequoia



47. SMALL MOUNTAIN MEADOW IN THE SILVER FIR BELT.

Many of the meadows in the Silver Fir Belt are like this one in the picture, very narrow and extending sometimes for a long distance through the trees. In the distant past they were undoubtedly much wider, but the forest has been gradually encroaching from both sides and it is only a question of time when in many of them the forest will close up and the meadows cease to be.

46. FOX-TAIL PINES ON THE SIDE OF AN OLD CRATER.

Of the trees of the Upper Pine Belt the Fox-Tail Pine seems to choose the dryest and warmest spots, while the Tamarack Pine and Hemlock Spruce grow where it is more moist and exposed.

forest are no wider than the height of the trees which hem them in. Higher up they are sometimes miles in length and a mile or more in width.

Those of the lower forests occupy spots which once were lakes. In the course of time the lakes were filled up with the fine rock waste and soil washed into them by the incoming streams and the growing of mosses in the lake itself. The fallen trunks of trees and the accumulation of pine needles also helped much. When the lake was quite filled, the mosses disappeared, grasses and flowers took possession and the mountain meadow came into being.

There are now very few meadows in the middle or lower portions of the Main Pine Belt. But in the far past

48. BIG TUOLUMNE MEADOW.

This is one of the largest meadows in the Upper Pine Belt. It occupies a basin that was once the gathering place of glaciers which moved down from the surrounding mountains. The Tuolumne River winds down through it. Forests of Tamarack Pine border both sides and in many places occupy spots within the meadow itself.

there were many as beautiful meadows there as are now found in the Silver Fir Belt, but being farther down the slope of the mountain, they were formed much earlier than those farther up and have ceased to be meadows, on account of the draining of the soil and the encroaching of the forest, until they have been entirely covered with trees. This in time will be the fate of those which are now found in the Fir Belt.

The meadows of the Upper Pine Belt for the most part occupy valleys which were once the gathering places of the glaciers that moved down from

Photo. by James Rennie.

49. UPPER FUNSTON MEADOW.

This is a view looking across one of the large meadows of the Upper Pine Belt. This meadow undoubtedly in the past was a shallow lake; even now the soil which covers it is too wet and soggy for trees to grow, and it will be a very long time before the place is occupied by the forest.

the surrounding mountains. Usually now a stream, sometimes a good sized river, flows through them. These open meadows are at so high an altitude that the grasses do not start until late in May or June and the flowers are not in full bloom until late in July or August. They are frequently bordered by a thick forest of tamarack pines which appears as a dark green belt separating the lighter green of the meadows from the gray and snow-clad mountain ranges above timber line.

50. LAKE MERCED.

Lake Merced is a beautiful sheet of water about 15 miles above the Yosemite Valley. The Merced River flows through it. The lake owes its existence to the old glacier which scooped out a great hollow in the granite, leaving a ridge of rock at the lower end which now holds back the lake. The mountains rise so abruptly from the sides of the lake that there is no passage left between them and the water. It is deep and clear, and in the early morning before the surface is ruffled by the breezes, the mountains and trees are reflected with startling vividness.

III.

KNAPSACK TRIP IN THE HIGH SIERRA.*

Late in July, seventy of the Sierra Club were camping near Lake Merced, a mountain-hemmed stretch of the Merced River some ten or twelve miles beyond the Yosemite and about three thousand feet higher. They had "hiked" from the main camp at the Tuolumne Meadows over snowfields lying on the ten thousand foot pass of Vogelsang and down the canon of the cataract torrent of McClure's Fork.

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*The Author's account of a trip in the High Sierra, published in the Sierra Club Bulletin, June, 1908.

For all its altitude, they found the walled-in valley around Lake Merced was summer-land. But the summer-land was bordered by spring, for the mountain walls still wore their crowns of snow, from which everywhere silver streams dropped down in cascades and waterfalls. Beneath the line of snow the bare granite walls glinted in the sunlight, excepting where crack or crevice gave scant opportunity for a dark evergreen to establish its home and where some shelf or gentler slope furnished space for a thin fringe of larger trees. The floor of the valley is timbered. Some places the forest is open, with great yellow pines and balsam firs stretching their crowns high heavenward and having at their feet a carpet of ferns and flowers. Along the streams are dense thickets of young cedars, and by the lake a fringe of aspens.

Truly Lake Merced is a glorious place to camp, and the Sierra Club enjoyed it to the utmost. But they were camping on schedule time, and the schedule called for only three days at Merced. There were other scenes to visit. Most of them first returned direct to the main camp at Tuolumne Meadows. But fifteen of the hardier ones, hearing the irresistible call of the mountains, put their beds and five days' provisions on their backs and started for Mt. Ritter, twenty miles to the eastward. And such a twenty miles! There is not a more glorious stretch on the continent! Now on some pass which is but a little lower than the peaks on either side and from which in every direction are seen piles on piles of mountains, all clothed in white and piercing the skies! Now in some gorge that seems like a titanic rift in the earth's crust! Now on a glacier-planed slope that might well be a giant's toboggan-slide! Again taking an angling course up a snow steep or sliding down one so swiftly that it seemed like flying through space! Then crossing rivers on snow bridges! The joy of it all calls irresistibly, and we long for the mountains again with a feeling akin to homesickness.

After a leisurely breakfast on the morning of July 23d we left the Merced camp, accompanied by nearly all the remainder of the Merced party of

Photo by R. T. Jones. **51. OUR CAMP AT LAKE MERCED.**

At the upper end of the lake there is a flat which is covered with pines and cedars, making a beautiful camping place. In this region during the summer no tents are used. The beds of the campers are usually under the pines or cedars and made upon pine needles and balsam fir boughs.

seventy, who went along partly to see us off and partly to visit the basin of the Upper Merced a few miles above.

Our packs were collected and sent forward on pack animals, which were to go as far up the gorge as possible and thus relieve us of some of the fatigue of the first day's tramp. Our way lay close to the river on the north side. We followed an old sheep trail, which was so indistinct that in many places we entirely lost it and had to push our way through brush and over broken rock masses which strewed the face of the rather abrupt cliff. The pack animals found the going very difficult and after a couple of miles were finally brought to a full stop by a glacier-polished granite slope that plunged into the river at a steep angle, and

52. CROSSING THE MERCED RIVER ON A LOG JAM.

which was even too smooth and abrupt for man to cross. Here we shouldered our packs and crossed the river on a convenient log bridge. We followed close to the river on the south side as far as Lake Washburn.

Lunch was eaten at the foot of the lake, where the Merced flows out in a clear stream from twenty-five to thirty feet wide and several feet deep. From here our course lay around the south shore of Lake Washburn. There was no trail whatever, and the going was very difficult on account of the great amount of talus and the thick brush. A few of those in the Merced party who had made their way high above the glacier slope which had forced us to cross the river were on the north side of Lake Washburn. Later they joined us above the lake, crossing the river on an old sheep bridge. They reported a fairly easy passage along the north shore of the lake.

East of Lake Washburn two or three beautiful little meadows were crossed, and some of the party discovered a soda spring, similar to the one in the Tuolumne Meadows. This find was an important one, as the spring will offer an extra attraction and induce travel to the basin of the Upper Merced. We reached the basin about the middle of the afternoon and halted to rest on the south side, just opposite where Triple Peak Fork runs down from the east. The basin is a great glacier-polished bowl, the walls of which rise to a varying height from 1,000 to 1,500 feet, down the face of which drop a number of cascades and falls. The most important of these are Triple Peak Falls, with a descent of nearly 1500 feet and the falls which drop into the basin from the south.

It had been our intention to camp in the basin for the first night; but it being still early in the afternoon, we decided to climb the rim and have the advantage the next morning of starting fresh from that point. We bade good-bye to our companions and took the way to the foot of the Triple Peak Falls. Most of the party crossed the river and climbed the cliff on the north side of the falls, but a few, discovering a cleft running up diagonally on the south side, chose that way. The ascent was difficult in a few places on account of the smooth surface of the glaciated granite, but there is little danger in the climb on either side of the falls.

From the top of the falls there is an unobstructed outlook down the Merced Valley to a mile or so beyond Lake Washburn, a distance of four or five miles. There was a beautiful view of it as it lay in the full moonlight, and we lingered until the lateness of the night warned us that sleep was needed for the tramp of the morrow. We reluctantly turned from the sparkle of the moonlight on the spray of the falls and were soon buried in sleep beneath the tamarack pines where the camp was made.

We were awakened along in the morning by the patter of heavy raindrops and there was hasty rising and hurrying about to get things under shelter; but it proved a false alarm and in a few minutes the moon was shining again.

We had another glorious view of the Merced Valley as the early morning light crept into it, then shouldered our packs again, turned our faces to the northeast, and followed up to Foerster Creek. Our course lay in this direction for a couple of miles, when we turned to a due east direction. About where our course changed we crossed the Isberg trail at right angles. We might have done so without seeing the trail, if we had not known it should be somewhere about that spot. It is marked by an occasional blaze and a "duck" monument here and there. Just where we crossed it there lay the half of a muleshoe, another evidence that man sometimes passed this way.

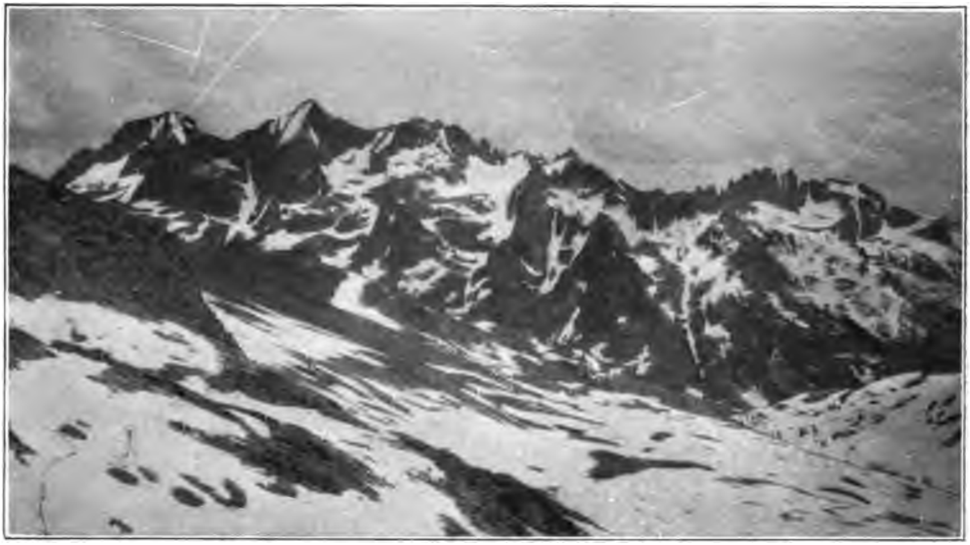
Just beyond the Isberg trail we passed on to the snowfield, which soon

53. A SNOWY RANGE, THE MERCED GROUP.

In the foreground there is one of the steep snow slopes up which traveling is very tiresome. In the distance is the Merced Group of Mountains, one of the minor ranges extending westward from the Main Divide. This picture was taken late in July. From the amount of snow still on the slope of the mountain some idea can be formed of the great amount that must fall during the winter and the lateness of the season before most of the surface is clear of snow.

became continuous, and for the next three days the greater part of the tramping was over snow. We were climbing all the time, too, and by the middle of the forenoon were so high up that the whole range south of the Merced stood out,—a great semi-circle of snow, beginning with Clark Peak on the west and extending through Gray, Red, Ottoway, Merced, and Triple Divide to Isberg on the east. It was a magnificent view and one exceeded only by that of the Ritter Range which we reached a few hours later.

We climbed up the west side of the north extension of the range in which Isberg Peak lies, between Foerster Peak and Long Mountain. It was a hard pull up the snow steep.



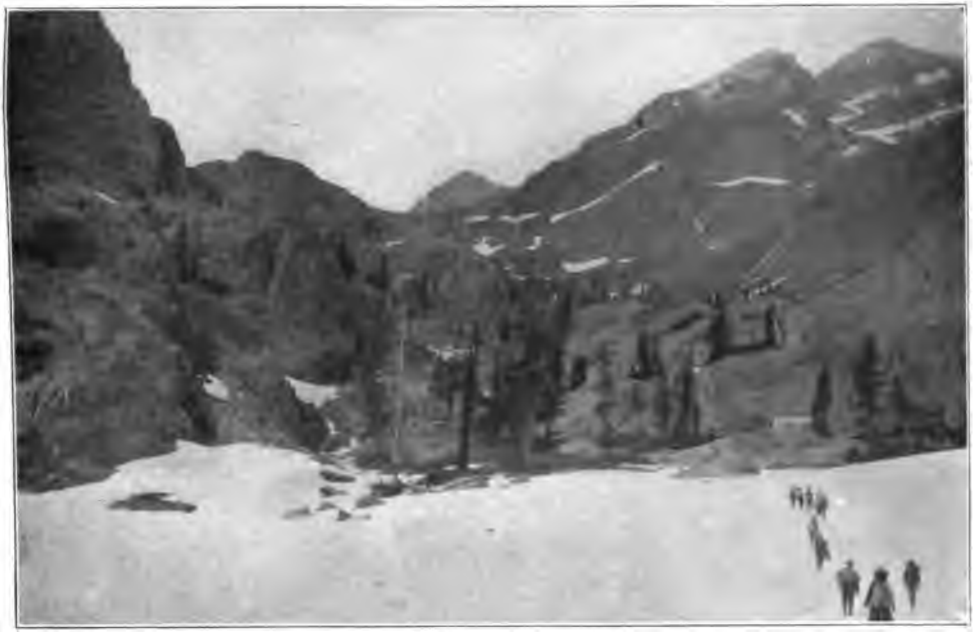
54. THE RITTER GROUP.

The high peak just to the left of the center is Mt. Ritter. Its altitude is 13,150 feet. Banner Mountain, which is almost as high as Ritter, shows to the left. The Ritter Group is one of the bleakest and most alpine of all the sub-groups of the Sierra Nevada. It rises fully a mile above the Canyon at its base.

The surface was deeply pitted and was softening under the warm sun, which made the tramping heavy. But just before noon we reached the summit of the ridge south of Foerster Peak at an altitude of about 11,500 feet.

It was a difficult climb to the top of this ridge, but as our heads rose above its crest, there burst upon our sight one of the most magnificent views in this part of the Sierra. Due east of us, six or seven miles in an airline, the Ritter Range, from Banner Mountain on the north to the Minarets on the south, stood out cold and gray against the sky. The San Joaquin Canyon lay between, the crest of the range rising to the height of nearly a mile above its lowest depth. In getting down to the San Joaquin we encountered some of the most ticklish work we found on the whole trip.

We struck the river at the foot of a long series of falls and cascades,



55. CANYON OF THE UPPER SAN JOAQUIN RIVER.

This canyon is deep and profound, and in places on its floor the snow lies throughout the entire year. The snowfield showing in the picture runs from side to side of the canyon, completely hiding the San Joaquin River. The place where this picture was taken is just under the west side of Mt. Ritter.

where the climb immediately began again. We found the floor of the canyon quite generally covered with snow and the stream spanned here and there by snow bridges, which made it very convenient for us, as we were forced from one side to the other by the wandering of the river.

We knew we were somewhere around the base of Ritter, but were laboring under the difficulty that always happens when one is immediately under the mountain one is looking for,—that of determining which is the right one of a group, all of which are visible.

We learned from a prospector that there was an old sheep trail leading up on the east side of the canyon, so we decided to chance it, and began the climb. It was now getting late in the day and we hastened as much as possible, but the fatigue of the long day's tramp was beginning to tell, and it was fully an hour before we reached a little basin at timber line, which here cannot be much below 11,000 feet. When we went into the camp, dusk was already gathering. While we were busy making camp, our leader climbed another five hundred feet to determine, if possible, whether it was really Ritter that was looming above us, but he was forced to return on account of darkness, and we went to sleep that night in uncertainty.

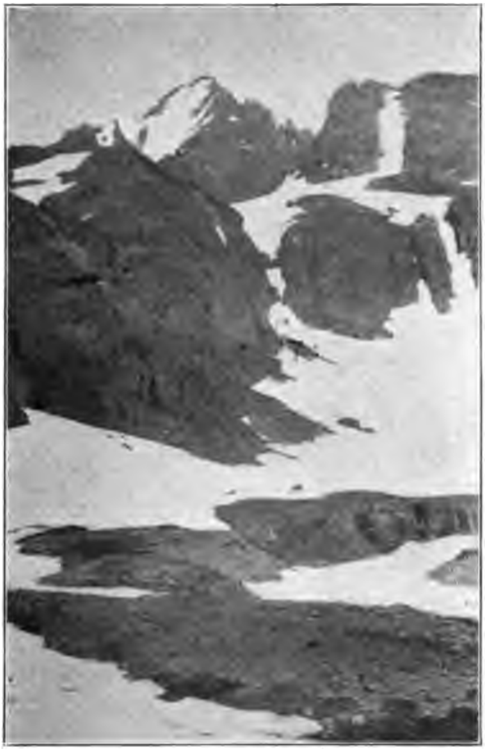
Although the moon was still nearly full, the mountains on the east were so high that deep darkness soon fell on the camp and we had to finish our preparations for the night by the light of the campfire. There was a little creek in the basin which dropped from a high altitude just a short distance back of the camp. In the evening there was quite a large volume of water coming over these falls, and the pounding and splashing of the water reminded us of that of the Yosemite Falls, which we heard all night long while in the Yosemite camp. The music of the waterfall lulled us to sleep, but when we were astir again at four in the morning everything was quiet. The creek was only a trickling rill and the snow bank beside the camp was a hard mass of ice. The night was one of the coldest of the whole outing.

We were away by five. We realized there was a hard day's work ahead of us, but fortunately could not see that it would stretch out to nearly

56.
A SNOW BRIDGE OVER THE SAN JOAQUIN.

fifteen hours, and that darkness would be falling again before we had picked a camping place for the night.

We were compelled to make a detour to the north in order to surmount the rim of the basin. With reluctance we turned our faces from the direction where we knew Ritter lay. Immediately there was a stiff climb which took away our breath, but offered no other particular difficulty. Gaining the top of the cliff, we turned to the southward and followed close along its edge. The face of the wall was so nearly perpendicular that frequently we could not see the floor of the basin close along its foot. We passed directly above where we had camped, crossing by one good step the stream which the evening before had furnished so much water for the falls. Here we changed our course to the southeast and began climbing again.



57. WHERE WE SPENT THE NIGHT BEFORE CLIMBING MT. RITTER.

Our camp was made at the very upper edge of the timber line, along a stream which in the evening was a roaring torrent, but which in the morning was frozen nearly dry. The place of our camp shows in the lower right hand corner of the picture. Altitude nearly 11,000 feet.

We were not yet certain which of the peaks in front of us was Ritter. As we advanced our doubts became more and more perplexing. We realized that climbing the wrong peak meant lots of unnecessary hard work and the loss of a day's time. By the general contours of the topographic map the mountain in front of us should be Ritter, but the lakes laid down did not exactly correspond to those we found. Finally, deciding that it is always better to determine to a certainty your mountain before climbing it, two of the party were sent to make a reconnoissance to the northeast, while the others rested.

With the aid of the map the scouts located Banner Mountain to the north, from which it was easy to determine the position of Ritter. It was a great relief to the whole party when they returned with the report that it was indeed our mountain which loomed above us. With joyous hearts we cached our packs on a convenient ledge, stripped ourselves of all unnecessary weight, and started on the last fifteen hundred feet of the climb.

We crossed a lake still hidden by many feet of snow, excepting along one margin where the ice had parted from the shore and where gleamed a long, thin crescent of brilliant turquoise blue. Beyond the lake we climbed a snow-buried ridge and passed into a cirque, at the bottom of which there must be true glacier ice. This cirque lies due west of Ritter and receives the snow which moves down its slope on that side. Looking southward from where we entered the cirque, the upper slope of the range bordering the east side of San Joaquin Canyon looked like the snow-clad roof of a giant's house. The slope leading from Ritter down into the cirque is trough-like and is twice broken by transverse ledges which extend part of the way across, and which undoubtedly indicate the location of dikes.

58. RITTER CRAGS.
This picture gives some idea of the rugged rocks over which we had to climb.

To avoid losing the elevation we had already made, we kept at a high contour on the north side of the cirque and gained the first of the two ledges above mentioned. From here we struck straight up the snowfield to the second ledge. This snow steep was of unusual difficulty, each pit merging into the one next below, until the surface became a succession of gutters approaching two feet in depth, with knife-like ridges between. To add to the difficulty, being on the west side of the mountain, until after midday the snow remained frozen as hard as ice.

We gathered on the second ledge and scanned the mountain wall, which surrounded the head of the snowfield, for a vulnerable point of attack. On our right the snow seemed to extend well up to the top of the ridge, but the way looked long and toilsome. Directly in front, not more than two hundred yards away, the snow ended and the rock crags rose nearly perpendicularly. Ordinarily we should have shunned such crags, but they "looked good" to us just then after the terrific work on the snow. A series of chimneys which split the crags made the prospect doubly alluring.

As the snow steep which lay between was extra hazardous, before taking the whole party up, our leader, followed by two others at distances apart, made an exploring trip. But the chimneys beat them back with the loss of nearly two hours, and we were forced to try the snowfield again. Steps were cut across the snow steep to some crags on the south, up which we climbed by some hand-over-hand work to the ridge which led directly to the top. A practicable route having once been discovered, there was no further delay, and shortly after one o'clock all the party were on the summit.

The day was fairly clear and the mountains in all directions stood out distinctly. But the haze hung over the desert and the bordering mountains were tinged with purple. In the northwest clouds overhung Mts. Lyell and McClure and Rodgers Peak, but from time to time they stood out distinctly. Banner Mountain, just to the north, appeared so close that it seemed as if one could reach it at a leap. Three or four miles southward the Minarets thrust into the sky their pinnacles, their flanks on the north and east clothed in white, while to the east and south of them lay piles on piles of mountains extending until the horizon and the clouds shut out the view.

Photo by Lena M. Redington.
59. ON THE SUMMIT OF MT. RITTER.

To the westward we looked across the San Joaquin Canyon, through whose deep recesses we had so lately come, to the range we had crossed the day before, and from which, in plain view, rose Electra, Foerster, Long and Isberg peaks. We could pick out the very spot where we had stopped to rest and satiate our souls with the glorious view.

The glacier on the southeast slope of Ritter was deeply covered with snow, which showed, however, the concentric lines indicating the direction of the downward movement. From our elevated position, the bergschrund on the opposite side showed distinctly.

About three o'clock we took a last look at the panorama of mountains and started down. The snow steeps, which caused us so much trouble in the ascent, had softened under the westering sun and there was some glorious coasting. Strenuous and exciting was some of it, too, on account of the steepness and the deep pits and gullies. All landed safely, however, on the snow-covered lake at the bottom of the slope. Picking up our packs, we started on our return to the Tuolumne camp. It was the intention to spend the night at Thousand Island Lake, some three or four miles north.

Around the lake we found everything covered with snow. There was scarcely a bare rock big enough for a single bed and certainly not one that had a soft side. Although it was now five o'clock we decided to push on over Island Pass into Rush Creek Basin, a distance of four or five miles. At Thousand Island Lake there was a small cache of provisions which the other Ritter party had left for us a few days before.

The snowfield continued all the way over Island Pass, and being deeply cupped and soft it made the way seem doubly long. There was a general sigh of relief when we reached the summit of the pass and began the descent. A mile farther on we made camp, but it was now so late that darkness fell before we had supper prepared.

Although it was in the last week in July, Rush Creek Basin was still pretty generally covered with snow. We found a camping place, however, on some granite ledges along a small creek a mile or so above the main stream.

The next morning the going was very hard. There was a stretch of four or five miles of nearly unbroken snow, the surface of which was deeply cupped and pitted. Being on the east slope it soon softened under the sun, and the steady ascent and heavy snow together made the tramp the most toilsome and wearysome of the whole trip. Though we were fresh from a night's rest, we were compelled to make frequent halts. It was about ten o'clock when we reached the top of Donohue Pass and began the descent into Lyell Canyon. A mile below the pass, while the remainder of the party continued on into the Tuolumne camp, arriving there early in the afternoon, five turned aside and climbed Mt. Lyell, thus accomplishing the unusual feat of ascending Mt. Ritter one day and Mt. Lyell on the day following.

Thus ended the Ritter trip, the first of the knapsack trips of the 1907 outing. That it was successful in every way is not saying too much. There was much toil and some discomfort, it is true, but these were far outweighed by the magnificence of the scene, the glory of the surroundings and the sense of freedom from worldcare. There is not one of us who would not again toil up the Foerster Ridge to view

The cold, gray range where Ritter keeps
Eternal watch and ward;
Whose crest is piled with granite heaps,
Whose flanks are wrapt in snowy steeps,
Adown whose gulch the glacier creeps,—
Sublime, majestic guard!

IV.

THE GREAT BASIN.

The term "basin" is used to indicate any area having a common drainage. "Drainage system" is also used to indicate the same thing. As popularly used it means a river system; but this is not always true, for there are many interior basins where the drainage is from all directions toward a common center; or the basin may be completely encircled by lines of water-partings and contain within its area a great many centers of drainage. Of the latter sort is the Great Basin.

The Great Basin was named by Gen. John C. Fremont in 1842, when he was on his great exploring expedition to the Pacific Coast. It had been visited by a great many persons previously, but the only one who had made any note of its peculiar drainage was Capt. Bonneville, an officer of the U. S. Army, who in 1833 was on leave of absence and traveling in the interest of a fur company. Capt. Bonneville's adventures were written up by Washington Irving and published about the time Fremont was making his expedition. Nearly fifty years before, Father Escalante made a trip across the southern part of what is now Utah, but he left no record that he saw anything peculiar about the drainage of the region.

The Great Basin includes nearly all of Nevada, the western half of Utah, large areas in southeastern California and eastern Oregon, and small areas in southeastern Idaho and southwestern Wyoming. An extension of the southern tip reaches into old Mexico. It covers about 210,000 square miles, an area nearly as large as the four states of Wisconsin, Illinois, Iowa and Missouri. The extreme length from northeast to southwest is nearly 900 miles, and the greatest width from east to west about 575 miles. Near the central part the elevation averages about 5,000 feet. While there are many stretches of nearly level areas, yet the Basin as a whole is broken up by smaller mountain ranges, all of which have a general north and south trend. These ranges are somewhat bunched near the center of the Basin, and divide it into an eastern sink, of which Great Salt Lake and Sevier Lake are the centers, and a western sink in which lie Lakes Humboldt and Winnemucke. Going south in Nevada, the surface gradually declines until in Southern California, in two places, Death Valley and Salton Sink, it drops several hundred feet below sea-level.

The water which flows away on the outer rim of the water-parting which encircles the Great Basin all drains into the Pacific Ocean. The Colorado River receives that from the east and south, the Columbia System that on the north and the Sacramento and San Joaquin Systems that on the west. For the most part, the mountains which form the encircling water-parting are high, and include some of the finest ranges of the United States. The Wasatch, Uintah and associated plateaus lie on the east, and on the west are the world-famed Sierra Nevada. These lofty mountains are largely responsible for the arid and desert-like condition of the Great Basin. In climbing the Sierra Nevada, the warm winds of the Pacific give up their load of moisture, and when they drop over into the Basin to the eastward are dry, and instead of yielding life-giving water, take up any they find in their way. Likewise on the east and southeast, the Wasatch and Uintah ranges rob the moisture-laden winds from the Gulf. How arid the region is may be gathered from the statement that the average annual rainfall is less than seven inches, while in the Central Mississippi Valley it is over forty-two inches; that is, the Great Basin receives less than one-sixth as much rainfall as Illinois, Iowa or the neighboring states. Then again the rainfall is not at all equally distributed. There are great cyclonic disturbances during which the greater part of the entire rainfall for the year

60. SAGE BRUSH OF THE DESERT.

This picture was taken near the mountains, where there is some rainfall, and shows the sage brush growing very thickly.

may come within a period of a few hours, and during the rest of the year there will be practically no rainfall whatever.

The slopes of the water-parting on the Basin side of the high ranges receive some moisture from the clouds which break over the top of the mountains before the winds have dropped to the warmer temperature below and while they are still giving off their moisture in the cold, higher altitudes. This moisture is deposited on the mountains in the form of snow, and thus forms a reservoir from which there is a continual flow of water throughout the year. It is in these reservoirs of snow that the Bear, Weber and Provo-Jordon Systems take their rise and to which they owe their existence throughout the year. These rivers all rise in the Uintah Mountains, break through the Wasatch Range in deep gorges and canyons, and after flowing through the desert-like plain of the Basin for considerable distances, flow into Great Salt Lake, which owes its life to the floods they bring from the mountains. The eastern slope of the Sierra Nevada, which forms the western rim of the Great Basin, does not furnish as much water as the slopes of the Uintah and Wasatch on the opposite rim, but still there is enough water to feed and maintain a number of lakes. The mountains extending north and south near the center of the Basin may be grouped under the name of the Eastern Humboldt Range. These mountains rise to such a height that when the western winds, rendered hot and dry after dropping from the heights of the Sierra Nevada and sweeping across the Nevada Sink, are forced upward again, their temperature is so lowered that they give up a sufficient supply of moisture to supply the Humboldt River system with a considerable stream. However, the Humboldt River traverses a dry and arid waste, and so much of its water is again taken up by the time it finds a rest in Humboldt Lake, it is so reduced in quantity that it can only support a lake of some five square miles in extent.

The uplands of the Wasatch Range are well timbered, and can be even said to have extensive forests; but otherwise, except for a little fringe along the Sierra Nevada, there is no timber of any size throughout the Basin. The vegetation consists mostly of sagebush, mesquit, rabbit bush and cacti. The Pinon, a dwarfish pine-tree seldom exceeding thirty feet in height, grows generally throughout the Basin on the low hills and lower slopes, but nowhere out on the plains. The Pinon bears a large seed that is an important article of food for the Indian. Generally the uplands of the bordering ranges are well supplied with grass and furnish good grazing; but while the soil is fertile, the altitude is too great for agriculture. The lower valleys of the slopes are quite generally cultivated and form the settled and prosperous areas of the Great Basin. The soil is wonderfully fertile, and wherever water can be secured for irrigation, crops are abundant. So generally have these valleys been settled that practically all of the water coming down from the mountains is now used for irrigation, and very little finds its way to the rivers of the lower plains through the open channels. There is considerable water in the lower courses of the rivers, however, but for the most part it has found its way through the gravel beds beneath the surface and has risen into the channels of the river after reaching the plain.

There are a number of large areas throughout the Basin that may be clearly called deserts. The four most important of these are the Mojave in southern California, which contains the celebrated Death Valley, the Colorado Desert, the Carson Desert in northern Nevada, and the Salt Lake Desert situated west and southwest of Great Salt Lake. The Escalante and the Sevier Deserts situated in southern Utah, are of lesser importance; and there are still others of a few square miles in extent.

There are no living streams in these deserts. Here and there, there are water courses along which, in time of flood occasioned by a cloud-burst, or other cyclonic disturbance, torrents may rush with terrific violence, but these floods usually subside within a few hours and leave the bed of the water-way dry again, with the exception of pools in the lower places.

It has been stated that the average annual rainfall for the Basin is less than seven inches, but the amount the desert portions receive is very much

61. ROCKS AND SAGE BRUSH IN THE RAINLESS DESERT.
Rocks and sage brush in a part of the Desert where there is very little rainfall at any time of the year.

less than this because of the mountainous portions receiving much the larger share. There are places on the desert which receive scarcely more than an inch of rainfall during the entire year, and it is possible some spots may receive no moisture whatever for a year at a time.

The soil of the desert is rich and if only water could be placed upon it, the region would be one of the most productive in the world. It is doubtful, however, if water ever can be obtained for much of it. The water coming down from the mountains which form the watersheds, is nearly all used for the land which lies on the slopes, and in some portions the ranches which lie farthest down on the slope toward the plain frequently suffer from lack of enough water for irrigation.

The hope of water for the deserts is in artesian wells. It is not yet known how generally water can be obtained in this manner; but already there are a number of oases in the Mojave Desert that owe their being to such wells. One crossing this desert on the railway notes occasionally a green spot of a mile or two in extent surrounded by the general gray of the desert. These spots are where artesian wells have been sunk, from which comes a flow of water sufficient to irrigate a limited area.

The deserts were greatly dreaded in early days of overland travel, and many cattle and horses were lost in making the passage. The lives of many immigrants, too, were sacrificed, before lines of travel were laid out that were sufficiently comfortable and safe. Immediately following the discovery of gold in California, the Government kept a number of parties in the region for several years surveying and mapping out routes of travel. Lives are still occasionally lost in these deserts, the victims being usually prospectors who are lured by the hope of treasure in the form of gold, silver or other metals.

Besides Great Salt Lake, Winnemucke, Sevier and other lakes, there are a great many other centers of drainage. Many of these centers are mere playas, or *alkali flats* as they are usually called. In the early summer, when the flow of water is greatest on account of the melting snows, many of these playas are lakes of considerable size and are practically fresh; but as the summer proceeds the water rapidly evaporates and soon there is nothing left but a white coated stretch of land. On some of these flats there is even not enough saline matter to make a coating of white, but the bed is composed of fine grained earth which contains a large amount of saline material. Sevier Lake is really only a very large playa, for, while during most of the time since its discovery it has contained considerable water, yet there have been short periods when the water was entirely evaporated and there existed nothing but a wide plain of salt four or five inches in thickness.

These salt lakes and playas are a vivid illustration of the fact that lakes which continually receive water but have no outlet, in time become salt water lakes. To emphasize this fact, one but needs to look at some of the other lakes of this region which are fresh water lakes because they have outlets. Utah Lake is an example of this kind. It receives the water of Provo River and has Jordon River for an outlet.

No doubt the object of greatest interest in the Great Basin is Great Salt Lake. This lake is very irregular in outline, having a number of large bays and projections, and containing islands of considerable size. Its extreme length north and south is about 75 miles and the extreme width about 50 miles. The present area is about 1,750 sq. miles. It has varied greatly in depth since 1849, when men began first to study it. The depth at that time was about what it is at present, but during the next twenty years it increased as much as thirteen feet. As the lake is very shallow and the shores flat, such an increase in depth greatly increased the size. A very large volume of water had to be added to make this increase. It is estimated that it required an increase of nearly 75 per cent. The addition of so much fresh water of course affected the saltiness of the lake. At the present time the water contains 25 per cent of solid matter, nearly all being common salt. In 1869, however, at the time of the high-water mark, the water contained only 13 per cent of solid matter. It is estimated that the lake contains about 400,000,000 tons of salt.

On account of the extreme saltiness of the water there is very little life present. The water contains no fish, the only animals found being shrimps and insects. The vegetable life is confined to a few seaweeds.

Great Salt Lake is but a dwindled remnant of an ancient lake which covered about 20,000 square miles, which was nearly 350 miles long, 145 miles wide and in some places as much as 1,200 feet deep. When you stand in Salt Lake City or at other places in the region of Great Salt Lake and look up at the encircling mountains, you can see the beach lines of the ancient lake high on the mountain sides. They frequently appear as great benches in series one above the other, showing where the shores of the old lake were at different times in its existence, and extend along the sides of the valley as far as the eye can see. This ancient body of water is known as Lake Bonneville, and geologists tell us that many thousands of years ago its waters were fresh and contained fish and other animal life very much the same as that found in Lake Superior or any other fresh-water lake of today. The outlet of Lake Bonneville was at its northern extremity through Red Rock Canyon into Snake River.

Mention has been made of the great change of depth in Great Salt Lake. The water is comparatively shallow and therefore warms up the more quickly, causing rapid evaporation. It is estimated that sufficient water enters the lake each year through the various rivers running into it to raise the level five and one-half feet, yet the level is continually, although slowly, sinking, showing that the evaporation is more rapid than the water supply.

Since the water is so heavily charged with salt, it is found profitable to manufacture salt for table use

62. VIEW IN SALT LAKE CITY.

Brigham Young's residences. The Lion House and the Bee Hive House in the foreground. In the distance is the north end of the Wasatch Range.

from it. The process of manufacture is largely one of evaporation. Large shallow reservoirs are constructed near the shores into which the water from the lake is pumped. When the water has evaporated from these reservoirs the salt is found crystallized at the bottom. The reservoir is again filled, and again the evaporation takes place. This process is continued until the deposit is several feet in thickness. The crude salt thus obtained contains many impurities, so it is taken to the refinery and there treated by a process which prepares it for table use.

There are a number of bathing resorts on the shores of the lake which are annually frequented by hundreds of thousands of people. Since the water is so heavily charged with solid matter, a body will not sink, and even one who is not skilled in swimming may enjoy the peculiar sensation of floating on the surface of the water. Additional evidence of the extreme saltiness of the water is seen around the bath-houses. The stairways leading down into the water become so encrusted with salt that frequently it becomes difficult for a person to walk down them, and it has to be cut away like ice from stairways and steps in the winter time; and from the under side long "icicles" of salt are hanging. If a bather holds aloft a hand which has been in the water, in a few seconds he will find it dry and covered with a coat of fine salt, whose minute crystals glisten in the sunlight. On coming out of the lake a bather must take a fresh-water bath.

Scattered through the lake are a number of islands, some of them of considerable size. Nearly all of these are separated from the main shore by shallow stretches of water, and stock is frequently taken across for pasturage. Some of the islands contain springs of fresh-water while others are completely devoid of them.

The region is rich in minerals of various kinds. The silver mines near Carson City, Nevada, have long been noted and the recent discovery of gold at Tonepah, Goldfield and other places have made the state one of the most important gold-producing ones.

Gold, silver and copper are found in many places throughout Utah, and the ore produced in the various mines keep several great smelters in operation.

There are many valuable coal deposits in the eastern part of Utah which furnish a supply of excellent fuel for a large part of the Basin. In the Uintah Range there are valuable asphalt beds which are not worked much yet on account of their lying too far from the railroads.

A large part of the borax now used in our country comes from the western part of the Great Basin, Death Valley furnishing much of it. There are extensive deposits at other places which have not yet been developed and which make the supply almost inexhaustible.

The region abounds in fine building stone. Besides limestone and sandstone, which are widely distributed, there are granite and marble beds of fine quality.

By far the largest city in the Great Basin is Salt Lake City, which was founded by the Mormons in 1847. It lies about 15 miles east of the Great Salt Lake on the Jordon River and just at the edge of the foot hills of the

63. MORMON TEMPLE AND TABERNABLE, SALT LAKE CITY.

The temple is built of granite which was hauled by ox-team from twenty miles up in the Wasatch Mountains. It was forty years in building. The tabernacle is used for large gatherings. It will seat about 8000 people.

Wasatch Range. The city is laid out with very wide streets and blocks of nearly four times the ordinary size. Through many of the streets water is running in flumes alongside the curb.

Salt Lake City is the center of the Mormon Church. The principal buildings of the church are the Temple and Tabernacle, which with some smaller buildings, are situated in Temple Square. Temple Square is made up of four blocks and contains nearly 40 acres. The grounds surrounding the buildings are kept like a park.

There are several great smelters situated near the city in which gold, silver, copper and other ores mined throughout the Great Basin are treated. The output of these metals alone makes Salt Lake City an important point. Salt Lake City is an important distributing point from which goods are sent to all parts of the east and north portions of the Great Basin.

There are many large stores which supply the trade in this outfitting business.

Ft. Douglas is located near Salt Lake City. It is the most important military station in the Great Basin. Frequently a whole regiment of cavalry is stationed here.

There is a prosperous farming region, extending both north and south of the city. This land was that which was first settled, and, having plenty of water for irrigating, it is one of the wealthiest farming sections in the Great Basin.

Fremont called this region the Great Basin, not because it was the largest of the kind in the world but because there was nothing of its kind, anything nearly its size, in North America. There are a few others, but much smaller, basins of interior drainage within the limits of the United States. Most of these are in New Mexico and Arizona, but all told they do not exceed 25,000 square miles in extent, which is less than one-eighth that of the Great Basin.

All of the other continents of the world have a larger percentage of their total area in basins of interior drainage. About one-half of Australia, one-third of Africa, a little more than one-fourth of Eurasia, and one-fourteenth of South America is so drained; while in North America the area is only about one-thirtieth.

We usually think of the Great Basin as being a very large stretch of desert waste, but the Great Sahara exceeds it sixteen times and the deserts of Northern Asia twenty-three times.

APPENDIX

I.

GROUPING PICTURES FOR TOPICAL STUDY.

With nearly every topic treated of in the text, pictures are given which bring out the specific points touched upon. For this purpose, such pictures have been chosen as will most forcibly illustrate the point in question. Many other pictures given in the book might illustrate the same point very satisfactorily; but as a pupil's impression should be clear, distinct and free from confusion, it is deemed wise to use a special illustration, even at the expense of some duplication.

Besides, there is a decided advantage in presenting a number of pictures which duplicate one another in certain features, since these duplicated features must necessarily vary much in detail and degree, and the tracing out of the same feature in a number of pictures will give a broader and more thorough understanding of it.

In this book the pictures which may be thus used for comparative study are necessarily much scattered. For instance, one used to illustrate the glaciers might also bring out finely how the peaks and ridges were formed; another showing a pass might be especially useful in a study of the limitations of forest growth, etc. However, for topical study they are readily grouped.

To aid in this topical study, the following groups are suggested: (The figures given under each group heading are the numbers of the pictures referred to as they appear in the list of illustrations given on page 6 and which appear also under each picture in the text.)

1. General Mountain Conditions:
   a. On the age of mountains and the present activity of the tearing-down forces: 1, 2 and 54.
   b. On the comparison of an upheaved range and a volcanic mountain: 8 and 9.
2. The Tearing-Down Forces:
   a. The work of frost: 3, 10, 11 and 58.
   b. The work of glaciers: 14, 20, 21, 22, 23, 24, 25, 33, 48, 50 and 55.
   c. The work of running water: 6, 10, 32, 33, 34, 36 and 39.
   d. General weathering effects: 4 and 61.
3. General Apearance of the Top of the Range: 7, 12 and 30.
4. Crest of the Main Divide, the Ridges and the High Peaks: 10, 11, 12, 13, 14, 22, 54, 58 and 59.
5. The Passes: 6, 14, 15 and 16.
6. The Snowfields: 15, 17, 18, 19, 20, 21, 26, 53, 55 and 56.

7. The Canyons: 12, 16, 25, 29, 30, 32, 35, 36, 38, 39 and 40.

8. The Different Types of Waterfalls: 31, 33, 34 and 37.

9. The Timber-Line: 5, 6, 7, 12, 14, 45 and 53.

10. Character of the Range Above Timber-Line: 1, 5, 10, 11, 22, 24, 26, 53, 57 and 58.

11. The Forests: 17, 40, 41, 42, 43, 44, 45, 46, 47 and 48.

12. The Different Types of Lakes: 16, 24, 25, 26, 27, 28 and 50.

13. The Meadows and Their Relation to the Lakes: 47, 48 and 49.

14. Desert Conditions: 8, 28, 60 and 61.

In the Chapter on Picture Studies, the illustrations are taken up in order and attention called to the principal physical features which may be found in each. What is there given contains all necessary information for making the group studies.

II.

PICTURE STUDIES.

(The author gives for each picture in the text a statement of what it shows to the student who observed the scene itself and photographed it for the purpose of further careful study in connection with other facts.)

1. A view in the High Sierra.

This view shows mountain peaks, ridges, canyons, etc. The absence of trees indicates that it is above timber line. The altitude mentioned would also show this, as well as that it is above snow-line. The sharp peaks, narrow ridges, and rugged surface generally tell us that the mountains are in the prime of life. The glacial cirques show where in the past there have been heavy glaciers. The snow steeps which lie in the deeper gulches merge into real glacier ice at the lower end.

These facts can be brought out by questions and directions as follows:

Point out a mountain peak, ridge, canyon. Is the scene above timber line? Above snow line? What makes you think so? What would make you think that the mountains are not yet old? Point out where there have once been deep glaciers, and where there are snowfields which likely lead down to small living glaciers.

Now tell all that you see in the picture.

2. View in the Alleghenies.

This is a view of mountains in old age. The range has been subjected to such a long period of erosion that there are no sharp peaks, and the ridges are all rounded off. The valleys are broad and comparatively level. The forest extends through valley and over hill alike, showing that there is a general covering of soil. The farms also show the presence of soil on the mountain sides.

Questions:

Tell whether you think this a new or an old mountain region, and why you think so. What things indicate a general covering of soil? Compare this picture with No. 1 as to age, ruggedness, activitiy, of erosion, altitude, forest growth, etc.

3. Granite in the Sierra Nevada Broken by the Action of Frost.

The blocks of granite are of an even thickness, showing that it is here in layers. The sharp corners and edges tell us that the rock is very hard. The boulders in the background have been rounded off by the old glacier, and were left there when the glacier retreated. The forest in the background indicates that some soil has collected there. Soil is now collecting in the wide fissures between the rocks. Much of it is from the pine needles and cones.

Questions by which the above facts may be brought out:

What indicates that the granite is in layers? What would make you think that the rock is very hard? There are some boulders lying on top of the bed of granite. How did they get there? How do they differ from the blocks in the foreground? What would make you think that some soil had collected in the background? Can you see soil collecting anywhere else? What is helping to make it?

4. Sandstone Pillars.

The soil surrounding these pillars is almost pure sand which has come from the disintegration of the rocks. The rocks are rapidly crumbling through the agency of moisture and frost, but more through the action of the wind and sand.

Questions by which the above facts may be brought out:

What is the soil surrounding these likely to be? (Lead the pupils to see that the wind blowing the sand is probably the most active agency in destroying these rocks, and that water and frost can attack them much more readily than those in picture 3.) What would seem to indicate that the rocks are much softer than those in picture 3?

5. Timber Line in the Sierra Nevada.

By a close study it will be seen that the trees are largest in the lowest part. As this picture was taken in mid-summer, it would seem to show that the slopes would still be covered with snow when the snows of the next winter came. Also there would be a period of no longer than 2 or 3 months in which the trees could possibly grow. The soil of course must be where the trees are growing and has come from the disintegration of the rocks and from the decomposition of the pine needles. and the trees themselves.

Questions by which the above facts may be brought out:

Point out where you think the trees grow the largest. Describe what you think the trees must be like at the highest point that they are growing. This picture was taken about the first of August. How long a season of growth each year do you think the trees have? Where is there soil and where bare rocks?

6. Farewell Gap.

The tree line seems to be about on a level with the gap, the peaks above that height being bare rocks. This would show that the gap must be between 10,000 to 11,000 feet above the sea. The ascent to the top of the pass seems to be gradual and not difficult.

Questions by which the above facts may be brought out:

What seems to show that summit of the pass is about timber line? About what altitude above sea level would it be then? Do you think the ascent to the top of the pass is difficult?

7. General View Across the Top of the Sierra Nevada.

This view shows the summit of the range in the distance. Also some of the higher peaks west of the Main Divide and a number of canyons and ridges. Forests are seen only in the valleys. The rock ridge in the foreground is constantly subjected to the effects of frost, and the rocks are disintegrating somewhat rapidly. The rock waste is carried off by the running water which comes from the melting snow.

Questions by which the above facts may be brought out:

Point out the summit of the range. Pick out some of the higher peaks, canyons and ridges. Where do you find the forests? What keeps soil from forming on or around the rock ridge in the middle of the snowfield?

8. Abrupt Eastern Face of the Sierra Nevada.

This steep eastern slope was the result of the almost straight pushing up of the mountain range along an earthquake fault or fissure. There is very little timber on the slope on account of its being too steep for soil to collect. One of the steep canyons which are found on the east slope opens out into the valley near the center of the picture. The creek which runs across the foreground and which is bordered by trees, shows that there must be another canyon to the right of the picture from which it flows.

Questions by which the above facts may be brought out:

What caused this steep eastern slope?
Why does it have very little timber?
Point out a canyon which opens out into the valley from the mountains. There is something in the picture which shows there is another canyon to the right of the part showing in the picture. What is it?

9. Mt. Shasta.

Mt. Shasta is a volcanic mountain on which there were two craters. The rounded forms of the cones show about where they were, but the exact outlines of the craters can no longer be made out. The South cone (the one on the right in the picture), is considerably the higher. The most active eroding agency has been ice. The summit is still surounded by active glaciers. (See text for further information.)

Questions:

How was Mt. Shasta formed? What is its general shape? How has the shape of the top been changed? What eroding force has been most active? Is that force still active? Is much of the mountain above timber line? Compare this mountain with those shown in pictures 1, 2, 11 and 12.

10. Summit and South Wall of Mt. Whitney.

The granite is in layers and also broken by vertical seams, thus allowing the water to enter more readily. The alternate thawing and freezing breaks up the rock on the surface. The view is looking east. The layers of granite slope gently away from the east front. The slope is too steep for rock waste to collect.

Questions:

In what ways does the granite seem to be broken? What forces are most active in tearing it apart? Which way do the layers of rock seem to slope? Why is there no soil? Why is there no timber? Tell all you can about the picture.

11. Summit of the Main Divide South of Mt. Whitney.

The sharp ridge, the high peaks, the bare rocks and the absence of timber all show that this is the top of a high range. Note the apparently rapid disintegration of the rock along the gulches. A canyon runs across the picture from left to right just beyond the saw-tooth ridge.

Questions:

What things show that this is a summit of a high mountain range? Point out some of the gulches? What indicates that the rock along them is rapidly disintegrating? Find a canyon. Is the region above timber line? Above snow line? Tell all you can about the picture.

12. The Great Western Divide from the Summit of Mt. Whitney.

A large part of the area shown in the picture is above timber line. The dark parts in the centre are covered by forests. The Kern Canyon runs from right to left across the centre of the picture. The top of the Western Divide is above snow line.

Questions:

Point out the top of Mt. Whitney. The crest of the Western Divide. Is it above snow line? Point out the parts above timber line. Trace the Kern Canyon. Which way does the water drain? Tell all you can about the picture.

13. Summit of Mt. Lyell.

The summit is a sharp peak composed of very hard, angular granite blocks which weather slowly. On the very top there is a *cairn,* that is a monument of loose stones which someone has piled up. It is a common custom for the person who first climbs a high peak to build a cairn to show that some one has been there.

Questions:

What can you say of the rocks composing the peak? What is a cairn? What do the snowfields in the distance indicate?

14. Summit of Mono Pass.

One of the lakes lying on the saddle of the pass shows on the right. The rounded appearance of the saddle indicates plainly that it was once the bed of a glacier. The stunted pines are evidence that the pass is just at timber line. There is some little soil, for the place is level enough for it to collect. Most of the trees, however, are growing in crevices of the rock. The head of Bloody Canyon is just beyond the lake on the right.

Questions:

What caused the lake? What shows that a glacier once occupied the pass? Is the pass near timber line? Why? Why may there be some little soil? Point out the canyon into which the pass leads.

15. A deep Snowdrift in Mono Pass.

In a number of places in Bloody Canyon there are deep drifts like this which never entirely melt. The trail passes over several of them. Note the steep walls of the canyon and the lake near the center.

Questions:

Why does the trail pass over the snowdrifts? Can you see any reason why the snow might make a better trail than the rocks? What is the character of the walls of the canyon?

16. One of the Walled-In Lakes of Bloody Canyon.

As explained in the text, the trail over Mono Pass, on the east side, leads down Bloody Canyon. The lake is formed by a dike across the canyon. The walls on either side are nearly perpendicular. In the foreground the woman is putting a bandage on the leg of her horse where it has been cut by the rocks.

Questions:

What can you say of the lake and how it was formed? What about its depth and color? What does the woman in the foreground seem to be doing, and why is it necessary?

17. Snowfield in the Upper Pine Belt of the Sierra.

This picture was taken about the middle of July and, as the altitude is only about 9,000 feet, it would show that there must have been a very heavy snow-fall during the previous winter. The snow would probably all be gone by the middle of August. The rounded appearance of the valley shows a glacier once moved through it. Probably the large boulder on the right of the picture was left by the glacier. The trees would probaly not have a period of growth longer than three months.

Questions:

What indicates that there was probably a heavy snowfall during the previous winter? Would the trees have a long period of growth? What does the rounded appearance of the valley indicate? Where did the boulder on the right probably come from?

18. Deeply-Pitted Snow.

This picture was taken about August first. From the amount of snow still unmelted, it would probably lie until late in August. The surface is very rough and difficult to travel over, both when it is hard frozen in the morning, and late in the day when it has softened under the sun. From the size of the trees the altitude is not much less than 10,000 feet. Very little soil has collected, and many of the trees are growing in crevices of the rocks.

Questions:

How would the walking be over such a surface and what time of the day most tiresome? From the size of the trees, about what is the altitude? Would the snow be apt to last until late in the summer? Is there apt to be much soil here?

19. Coasting Down a Steep Snow Slope.

The snow showing in the picture fills a deep gulch, the walls of which are too steep for snow to lie on. The person coasting is following the track of some one who has gone down before him. This track indicates that the snow is soft; of course it is too dangerous to coast on such a steep slope when the snow is frozen; in fact no coasting is undertaken except on soft snow. The picture of the man is blurred, showing that he must have been coasting at a pretty good speed.

Questions:

What seems to indicate that the snow slope is in a gulch? What shows that the surface is soft and that it was probably late in the day when the man was coasting? What shows that he is going swiftly?

20. Ritter Glacier.

While this glacier is not as large as some others in the Sierra, it is one of the deepest. The movement of the glacier is towards the left, as shown by the concentric lines. The bergschunds on the opposite side of the glacier plainly show. The whole scene is above timber line and largely above snow line.

Questions:

Which way is the movement of the glacier and what indicates it? What are the openings or cracks between the glacier and the mountains on the opposite side? What shows that the scene is above timber line and snow line? Why would the snow which falls on the surrounding mountains soon move down and merge with the glacier?

21. Lyell Glacier.

This glacier lies in a cirque surrounded by a high rim of mountains, from which a number of peaks rise. The snowfields from which the snow moves down into the glacier show on the far side of the picture. The glacier ends near the center of the picture, the whole foreground being merely a snowfield which will be clear later in the summer. The rock ridges scattered over the foreground would indicate that the glacier does not move down that far.

Questions:

About how far down does the glacier extend? What shows that the foreground is merely a snowfield and not a glacier? Point out the snowfields which furnish snow to make the glacier? Why are the mountain peaks clear of snow?

22. A Sharp Ridge Between Two Cirques.

The sharp mountain peak was formed by glaciers which occupied two cirques showing on the right and left and other cirques on the opposite side. The glaciers which formerly occupied these two cirques moved down towards the front of the picture, and the lake fills a hollow in the rocks which they scooped out. The sharp ridge between the two cirques was made by the glaciers which occupied them.

Questions:

How was this peak formed? Point out the glacial cirques in the picture and the sharp ridge that divides them. Which way did the glaciers move in these cirques? How was the lake formed? Is the scene above timber line? Why? Tell all you can about the picture.

23. Glaciated Granite.

The whole area shown in the picture is bare granite, over which a glacier formerly moved. The boulders scattered everywhere were left by the glacier. There is no soil anywhere in the picture, and the trees are growing in cracks in the granite. No soil has formed because of the granite being so hard as to resist erosion, and therefore there is no rock waste.

Questions:

What seems to indicate that the whole surface is glaciated? Why is there no soil? What are the boulders like and where did they come from? Where are the trees growing?

24. Lake in Old Glacial Cirque.

The whole scene is above timber line and there is no soil showing anywhere, except what might collect in cracks and crevices of the rocks. The cirque opens to the right and is really the head of a canyon. The mountains showing beyond form the top of the Main Divide.

Questions:

Is this view above timber line? How was the cirque formed? Which way does it probably open out into a canyon? What caused the lake? Why do the mountains beyond look like they might be the top of the range?

25. Glacial Lakes in a Canyon.

These two lakes are the lower ones of a chain of glacial lakes occupying a canyon. They are separated by a ridge of hard rock. They are just above the timber line, as the stunted trees around the lower lake would show.

Questions:

What has caused these lakes? What separates them? What shows they are above the timber line? Which way do they drain? What is the general character of the surrounding country?

26. Snow-covered Lake in August.

The outline of the lake can just be made out in the lower right-hand corner of the picture. The natural fall of snow on this lake was increased by the snow sliding down from the steep slope of the mountain. It will probably be September before the lake fully thaws out. The whole scene is above snow line.

Questions:

What shows where the lake is? How was it probably so deeply covered with snow?

27. Mirror Lake, Yosemite.

This picture was taken in the early morning, before the breeze had ruffled the surface of the lake. The lake is a glacial one; that is, it occupies a hollow scooped out by a glacier. There is considerable soil surrounding the lake, as indicated by the dense growth of underbrush on the farther side, and the tall pines farther back.

Questions:

What time of the day was this picture probably taken? What indicates that some soil has formed around the lake? Where did it come from?

28. Lake Mono, From the Summit of Mt. Dana.

This is one of the salt lakes, at the eastern base of the Sierra Nevada, and in the extreme western side of the Great Basin. It is extremely salty, containing about 25 per cent of solid matter. It receives several streams from the eastern slope of the Sierra, but has no outlet.

Questions:

What has made this a salt lake? Why is there no vegetation showing around the lake?

29. Kern Canyon.

The Kern Canyon here is nearly due north and south for about 30 miles. Its walls are not so nearly perpendicular as those of the Yosemite and only about two-thirds as high. There is considerable soil on the floor and a good deal of rock waste along the sides. In some places the sides are steep rock walls and in other places slopes of loose talus. This is because the rock varies much in hardness. Trees grow pretty generally over the floor of the valley, and also up the sides wherever there is much talus. The part of the canyon shown here is U-shaped, indicating that a glacier once occupied it.

Questions:

Compare this canyon with the Yosemite as to the steepness and height of the walls, the character of the rock and the general shape. What shows that in some places the rock is hard and resists erosion, while at other places it disintegrates rapidly? Does there seem to be any soil worth while?

30. Tuolumne Canyon from the Top of Mt. Hoffman.

The canyon extends from the high mountains on the east across the center of the picture toward the west. The drainage of nearly the whole scene is into the Tuolumne river. This view gives a good idea of the extent to which the western slope of the Sierra has been sculptured by water, glaciers, frost and other eroding agencies. Much of the scene is at timber line, or higher. Mt. Hoffman is about 10 miles northeast of the Yosemite. The crest of the Main Divide shows clear across the picture in the distance.

Questions:

Point out the different physical features. Trace the Tuolumne Canyon and the main crest of the mountains. How much of the area drains into the Tuolumne? How near timber line is this?

31. Grand Falls of the Tuolumne.

The granite here is not massive as at the Yosemite Falls, but is bedded and more or less checked with vertical seams; hence it breaks up into blocks and weathers into terraces.

Questions:

Compare the rock here with that at Yosemite Falls. Which is the more massive? Which seems to be in beds? Which breaks up the more easily? What besides the water is helping to break up the rocks here?

32. Yosemite.

Looking into the valley from the lower end. The perpendicular wall of El Capitan shows that the rock must be very hard and does not disintegrate easily, while the high slope of rock waste at the left of the valley in the foreground indicates that the rock there does disintegrate easily. The timbered floor of the valley indicates a good deposit of soil.

Questions:

Point out the different physical features of the valley. Where is the rock hard and resisting disintegration and where is it breaking up more readily? What indicates there is a good depth of soil on the floor of the valley?

33. Falls of Triple Peak Fork.

The water has been flowing over the hard, glaciated granite for thousands of years, yet the stream has not cut a channel deep enough to form banks. What little soil there is, has collected on the flat at the foot of the falls. For the most part, the trees are growing in cracks in the granite. Steep as the slope is, there are still some boulders scattered here and there which were left by the glacier.

Questions:

What shows that the rock is very hard? Where has some little soil collected? Where are the trees growing? How do they help break up the rock? Can you find any boulders? How did they get there?

34. The Merced River at Vernal Falls.

This picture shows that the rock here breaks up more readily than that in picture 29. Where it has a chance to collect, there is more soil, too. Then the size of the trees shows that the altitude is lower.

Questions:

Point out the different physical features, such as the high canyon walls, the falls, the rapids, etc. Compare this picture with No. 29. Which rocks break up more readily? Where are the trees larger, and why?

35. The Merced River in the Yosemite.

Along the flat floor of the valley the Merced is a comparatively quiet stream and flows between banks of soil.

Questions:

Why is the river smooth and quiet here? What is the character of its banks? What shows there is plenty of soil?

36. The Merced River in the Upper Part of the Foot-hills.

The valley is V-shaped, showing absence of glacial erosion. The swift river indicates continuous drop in altitude. The sides of the valley are covered with brush and small trees, showing that the rock disintegrates readily and that soil is forming. The brush and scrubby trees indicate dryer climate than farther up in the mountains. Compare this picture with No. 31.

Questions:

Compare this picture with No. 31. What causes the difference in the river? Which has the larger trees? Why? In which are the rocks disintegrating more rapidly? Is the soil in different positions? Why is the valley V-shaped here?

37. Upper Yosemite Falls.

The high perpendicular wall shows that the rock is of uniform hardness and the small amount of erosion indicates that it does not wear away easily.

Questions:

What shows that the rock is of uniform hardness and does not erode easily?

38. Looking down into Yosemite Valley from the top of Yosemite Falls.

From this point the flat floor of the valley shows to the best advantage. The floor is well-covered with timber. Except in a few places, the side walls are too steep for trees to grow. The High Sierra, reaching above snow line, show in the distance. There is where the Merced River rises.

Questions:

Point out the different physical features? Where is there most timber? Why? What river flows through the Yosemite? Where does it rise?

39. Muir Gorge in the Tuolumne Canyon.

This gorge is impassable on account of the perpendicular walls and the narrow space between. The walls are as straight up and fully as high as those of the Yosemite.

Questions:

Compare the rock walls with those of the Yosemite. Do they seem to be as perpendicular? As high? What makes the gorge impassable?

40. Forest in the Main Pine Belt.

The trees are sequoias, pines and firs. Three of the great sequoias stand towards the right of the picture. The small tree on the extreme left is a fir. A sugar pine stands to the left of the center, leaning towards the center. This forest is about as dense as can be found in the Main Pine Belt. Nearly everywhere it is more open. The luxuriant forest growth shows a good depth of rich soil.

Questions:

Note the size of the sequoias as compared with the other trees, the difference in the bark and the absence of branches as far as the trunks appear in the picture. Also the density of the foliage where the coniferous trees grow close together. What is the character and depth of the soil? Where did it come from?

41. Trunk of a Yellow Pine.

The yellow pine, when growing under the most favorable circumstances, as this one in the picture, has a straight, sturdy trunk, which for the lower half of its length is of nearly the same thickness. Its bark is brownish-yellow and is divided into large plates. The yellow pines furnish many needles and cones to help make soil.

Questions:

Tell what you can about the trunk? How is the bark marked? What does the tree furnish to help make soil? Tell what you see scattered around on the ground.

42. Trunks of Two Giant Sequoias.

43. Top of a Typical Sequoia.

It is difficult to get a good picture of a full sequoia on account of its great height. By taking a picture which shows a trunk to good advantage, the top is usually dwarfed and out of perspective. But by taking separate pictures of the trunk and top, each from the best position, the proper perspective is preserved and a better idea of the tree as a whole conveyed. Picture 43 was taken from a rock ledge directly opposite the top of the tree and shows it in its perfect dome-like form. In 42, more than 125 feet of the trunk shows, or about one-half of the entire height. The part showing in 43 is about two-thirds of the tree. "Gen: Sherman," is much the largest of the three trees, and is probably double the age of either of the others. Its trunk has been scarred by fire. In studying the trees, note the straight trunks, the close bark, the sturdy limbs and the symmetrical top.

Questions:

Compare the trunks with that of the yellow pine in picture 41. What can you say about the trunk, bark, limbs and top? What caused the scar on "Gen. Sherman"? Why does the tree have such thick bark?

44. Forest in the Silver Fir Belt.

The forest is more dense than that of the Upper Pine Belt. The trees are tall and slender. The heavy growth indicates the presence of considerable soil, which has come from the decaying trunks and limbs and the constant accumulation of cones and needles.

Questions:

Compare the fir forest with that of the pine belt. In which are the trees more slender and graceful? Tell how soil is forming.

45. Tamarack Pines on Mono Pass.

These pines are just at timber line. They are dwarfed by the high altitude and crushed all out of shape by the great mass of snow which covers them during winter. This same tree, 2,000 feet lower, grows to nearly 3 feet in diameter. Such a sparse growth of timber would add very little to the soil.

Questions:

What is the altitude of Mono Pass? Why are the conditions unfavorable for tree growth? To what extent would the trees add to the soil? Why are the trees so dwarfed and crushed? Give a description of the whole scene.

46. Fox-Tail Pines on the Side of an Old Crater.

Although the fox-tail pine grows only at a high altitude, yet it likes the dryer places. It is not a large tree, only reaching a height of 50 or 60 feet. Its trunk is covered with limbs almost to the ground. Its limbs are short, pretty much of the same length and thickly set clear to the top.

Questions:

Compare these trees with those in picture 45. Which are the taller and more graceful? Which have the denser foliage? Which forest is the more open? Which forest occupies the dryer place? Give a description of the scene.

47. Small Mountain Meadow in the Silver Fir Belt.

A long, narrow meadow, through which a little stream wanders. In the far past this meadow was much wider, but the forest has gradually spread over it from both sides until only a narrow strip is left. In the course of time the trees will meet and there will be no meadow.

Questions:

Tell how you think this meadow came to be so long and narrow. What will finally become of the meadow?

48. Big Tuolumne Meadow.

This meadow occupies an old glacier basin. On account of its being so nearly level, soil has collected on the hard rock floor. In some places the soil is several feet deep, in others it is quite thin, while in a few spots the bare rock still shows. During the summer months the meadow is covered with grass and affords good grazing.

Questions:

Point out the different physical features in this picture. How was the basin formed which the meadow occupies? Where did the soil come from which covers the floor? Trace the course of the Tuolumne river through the meadow. Tell in a connected way all that you find in the picture.

49. Upper Funston Meadow.

A large meadow occupying the place where there was once a shallow lake. The soil is several feet deep, but is too wet and soggy for trees to grow. In the course of time, as the soil drains more thoroughly and dries out, the forest will creep in and occupy the meadow. However, such event is a long way off in the future.

Questions:

Why has the forest not yet occupied the place? Is the forest beyond on higher or lower ground? What formerly occupied the place? Does there seem to be a good deposit of soil?

50. Lake Merced.

The U-shape of the canyon and its smooth rock walls indicate that it was once occupied by a glacier. There is a flat at the upper end of the lake, where considerable soil has collected and which is covered with timber. (See, also, description under picture.)

Questions:

What indicates that a glacier once occupied the canyon? How was the lake formed? Is such a lake apt to be deep? Compare the forest growing on the flat at the head of the lake with that on the side of the mountain beyond. Which is made up of larger trees? Where is there any soil?

51. Our Camp at Lake Merced.

See description beneath the picture.

Have the pupils tell why the forest grew there; what the trees were, why no tents were needed, what the beds were made of, how the cooking was done, etc.

52. Crossing the Merced on a Log Jam.

The jam was caused by the logs lodging against a large rock near the center of the stream. The logs were the trunks of trees which had been torn from the mountain side by snow avalanches farther up the valley. The high spring floods had then brought them down the river. They are pine and fir.

Questions:

What kind of trees were the logs from? Where did they come from? How was the jam formed?

53. A Snowy Range, The Merced Group.

Note how the trees become fewer and fewer from the valley up the mountain side, until they stop altogether. (See description beneath the picture.)

Questions:

Trace the timber line on the opposite side of the basin. Where is the heaviest timber? Point out the part above snow line. What would indicate that the snowfall must be very heavy in this region? Does the basin look as if a glacier once occupied it?

54. The Ritter Group.

The different tearing-down agencies are actively at work on the Ritter group. Near the top of the range there are many fine cirques, a number of which show in the picture. (Consult the description beneath the picture, also.)

Questions:

Point out Mt. Ritter. What is its altitude? How high is its summit above the canyon at the base of the mountains? Which is Banner Mountain? Point out some glacial cirques. What tearing-down forces are now active on the Ritter Group? Describe the group.

55. Canyon of the Upper San Joaquin River.

This is near the head of the North Fork of the San Joaquin. The view is near timber line. The rounded floor and smooth walls show that it once held a glacier. Very little soil has collected. The river flows for a long distance under the snowfield at the left.

Questions:

Where is the river in the picture? Is the place near timber line? Why? Is there much erosion now going on? Tell whether or not the canyon was glaciated, and why you think so.

56. A Snow Bridge over the San Joaquin.

Tell what you can find in the picture besides the snow bridge which spans the river.

57. Where we spent the Night Before Climbing Mt. Ritter.

Most of the mountain side is too steep for snow to lie. The whole scene is above timber line and almost wholly above snow line.

Questions:

Why is not more of the mountain side covered with snow? Where is the timber line? Snow line? Would it be apt to freeze hard here at night, even in the summer?

58. Ritter Crags.

The ridges leading up to the summit are composed of crags like those in the picture. Their sides are covered with snow wherever it can find a place to lodge. When this snow is frozen, it is more difficult and dangerous to climb over than the crags. The rough, angular form of the rocks is the work of frost.

Questions:

What causes the rough, angular form of the rocks? Why should frozen snow be more dangerous to climb than the rocks?

59. The Summit of Mt. Ritter.

Have the pupils give a general description of what is seen from the summit, based on what is given in the text.